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Heavy and Light Cropping in Alternate Years.

A Serious Defect of the Australian Apple Industry.*

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1. Introduction.

While studying, during the past three seasons, the factors affecting the condition and quality of stored and exported apples, certain facts relative to the apple-growing industry in Australia have become apparent.

Apple-growing is in a state of depression which has become increasingly marked since 1926. This statement applies to the industry in Australia as a whole, but not to all of the States. One indication of the position is to be seen in the decline in the planted area in Tasmania, Victoria, South Australia, and Queensland. This dropped from 77,701 acres in 1925-26, to 73,669 acres in 1927-28.† Against this, there has been an increase in New South Wales and Western Australia from 20,676 to 24,566 acres‡ in the same period. The net result has been a slow drop in acreage for the Commonwealth as a whole. It is obvious that apple-growing in the former States has been more affected than in the latter. It is the object of this paper firstly to analyse the causes of the decline in the former States—which have over 70 per cent. of the total acreage—and the relative prosperity of the industry in the others. Secondly, it is hoped to draw attention to the need of finding ways and means of overcoming these causes, without which the industry in Australia as a whole will continue to decline.

Evidence of the unsatisfactory condition of the industry may be found in the decline in the planted area and in the relation of the prices received to the costs of growing and marketing. The latter will be referred to later. In regard to the former, it should be realized that a fall in acreage lags behind a fall in prosperity. It requires a succession of unprofitable seasons before orchards are deliberately destroyed or abandoned. The first fact which becomes apparent is that the prosperity of the industry is lowest in those States—with one exception—which have the greatest export. The decline has been greatest in Victoria, Tasmania, and South Australia, which collectively contributed 84 per cent. of the quantity exported during the seasons 1925-26 to 1928-29. It would therefore seem, and is generally

* Received for publication, September, 1930. † 71,515 acres, 1928-9. ‡ 25,196 acres, 1928-9.

admitted, that the export trade has, on the whole, been unprofitable. Some of the factors operating detrimentally in respect to both the export and Australian markets are of long standing, others are of relatively recent origin, and one has recurred at intervals in the history of the industry. Those of most importance are:—

1. Increased costs of growing and handling the fruit.

2. Lower national purchasing power in both Australia and Europe.

3. Insufficient care in packing for storage and export in respect to grading for colour, quality, and general get-up, and in selecting only fruit in a sound and satisfactory condition.

4. Excessive number of varieties, many unsuitable for the export trade.

5. Insufficient organization of the export trade.

6. Import duties in Germany higher than those for fruit from Australia's principal competitors, United States of America and New Zealand.

7. Increased competition in recent years in Europe from United States of America and New Zealand. This has led to the increasing importance of the points given in 3. There is no evidence that exported Australian fruit has been inferior in recent years to what it was formerly. The defects have become more important owing to increased competition from fruit of better quality and condition.

8. Most important of all, because of its relation to the other factors, has been the marked fluctuation of production in alternate years since about 1925. This has upset marketing in Australia. It has disorganized work on the orchard in the heavy seasons, and has been a factor operating against due care in the selection and packing of export fruit. It has disorganized overseas marketing in the heavy years. Further, there are indications that it has been the important factor in hastening or delaying the time of maturity. Uncertainty as to when the fruit will be ready to ship has been one cause of the export of immature fruit.

Increased costs are largely beyond control by the industry, but lowered purchasing power abroad certainly is outside its control as is the duty on Australian apples imposed by Germany. Lack of efficient organization by the export trade is partly the result of production fluctuations, and partly of its earlier history. Exporting started independently in the several States, and still continues on the same lines. They compete in Europe against each other as well as against New Zealand and United States of America. New Zealand, on the other hand, exports the greater proportion of its apples under a single organization, which controls both the packing and marketing ends. This organization, rather than the quality of the fruit produced in the orchards, has been responsible for New Zealand fruit averaging 2s. to 3s. per bushel better than Australia. This difference is due mainly to the low prices received for Victorian and Tasmanian fruit. Prices received for South Australian, and particularly for Western Australian, compare favorably with those obtained for New Zealand apples.

Lack of care in the selection and packing of export fruit is partly due to orchard organization breaking down under the weight of very

heavy crops. To a larger extent, it is due to a lack of realization of the changed conditions in the export trade. When Australia was practically the sole supplier of apples on the European market during April to July, less attention was paid by buyers to quality and condition. In recent years, however, United States of America and New Zealand have vastly increased their competition on this market. The generally superior quality of the fruit from these countries has thrown into prominence the frequent defectiveness of Australian apples in quality, condition, and attractiveness of pack. Further, growers have not realized how responsible they frequently are for these defects. There has been a tendency to throw much of the responsibility on to the shipping companies, ignoring the fact that New Zealand fruit develops far less deterioration, although it is carried by similarly equipped, and frequently the same, boats. Complaints of immaturity are admitted as being due to the condition of the fruit when packed. It has not been generally realized, however, that wastage and deterioration may also be due largely to the pre-shipment condition. Apples which are immature or too mature, or which contain watercore, are particularly subject to deterioration. There has also been a lack of appreciation by growers of the fact that an attractive appearance is the surest guarantee of profitable sales. Not only should the cases be of good appearance and attractively labelled, but the contents should be of uniformly good quality, condition, and colour. The varieties should be those in demand by buyers, and the quantities sufficient to attract the larger buyers. Too many varieties are sent at present, and frequently in numbers too small for the average purchaser. The writer has been particularly struck with the lack of uniformity in maturity and colour in exported fruit. Satisfactory results can be obtained with certainty only when the various factors acting on and in the fruit are known and allowed for. Keener competition can only be met by better fruit and better marketing.

The matter of the definite up-and-down fluctuation in apple production has apparently received little attention so far. It is to this subject that attention is principally invited by this article.

2. Alternate Heavy and Light Cropping.

Since 1925, there has been an extraordinary annual fluctuation in the Australian apple production. This has been accompanied by a similar fluctuation in the quantity exported, and this, in turn, has exposed the weaknesses of the present export marketing methods. The several States compete against each other. Markets may be and are oversupplied at one period and undersupplied at others. No central organization is available to arrange shipping or the distribution of supplies, or, when desirable, to alter the markets of consignments in transit. The existing arrangements in the orchard, in handling and in marketing, both in Australia and abroad, tend to break down under the weight of the heavy crops.

Reference to Fig. 1* will show that the fluctuations have created alternate gluts and shortages in Australia. In the graph, the line indicating normal consumption is calculated on a basis of three-quarters of a bushel per head of population. This is certainly close to the truth in Western Australia, where neither gluts nor marked shortages have occurred in recent years. Even if the true Australian figure varies

* See plates, page 124 *et seq.*

somewhat from this, it is unlikely that the difference will affect the result to any extent. It is also clear that the shortages in 1926-27. and 1928-29 were due to the quantity exported. Nevertheless, the export of 1,600,000 bushels in 1928-29 was justified by the need of keeping Australia represented on the markets. In the heavy years 1925-26, 1927-28, and 1929-30, the export averaged 4,000,000 bushels, which was not sufficient to prevent gluts in Victoria, Tasmania, and South Australia. The shortage in light years has affected mainly Victoria, New South Wales, and Queensland. Victorian and South Australian growers have not obtained sufficient profit in the light seasons to make up for their losses in the heavy. Tasmania and Western Australia have benefited by the high prices in New South Wales and Victoria in the short-crop years because both have had sufficient fruit to market there, the former by reducing its overseas export, and the latter because of its heavy crop. In the seasons of heavy crop in Australia, local prices have been low, except in the western State. The latter has benefited as a result of its short crop combined with the quantity exported. It should be recalled that no apples are allowed into Western Australia, a precaution against the introduction of codlin moth.

The export trade from Australia has been regarded mainly as a means of stabilizing prices in the Commonwealth. Generally speaking, it has not, of recent years, returned the costs of growing and marketing, except in Western Australia. Consequently Tasmania, always with a large surplus, adjusts its export to mainland prices. In 1925, the last year before the present Australian annual fluctuation became so marked, it marketed 40 per cent., or about 900,000 bushels, in Australia. Since then it has marketed in Australia, in years of heavy crop and low local prices, 42 to 49 per cent., and in light years 60 to 64 per cent. It is apparent that the European trade is not functioning as a price regulator to the extent of yielding a satisfactory net profit to the industry. The heavy crops are in excess of the quantity which Australia and Europe can together absorb profitably under present conditions. Western Australian fruit benefits by special circumstances which have made exporting profitable. The quantity exported has been relatively small, 160,000 to 655,000 bushels, or about 5 per cent. of the Australian export in heavy years, and up to 40 per cent. in the light. The quality and condition of this fruit has been well above the Australian average, and in consequence has been in demand, particularly in the Continental markets. Over 80 per cent. is purchased in the State at f.o.r. prices profitable to the grower. These prices are due to competition for a special and limited line, and do not necessarily indicate the true value on the market. Nevertheless, it is more than probable that Europe could absorb, at profitable prices, a somewhat smaller amount than is now sent in heavy years, if the condition and get-up of the fruit and the organization for marketing were improved. Australian fruit should compete more than favourably with American fruit, as it is marketed only some two or three months from picking, as against the five to seven months for the latter, on the same markets.

Costs of production and marketing in Australia are approximately 2s. 6d. to 3s. 6d. for growing, 2s. for case, packing, and incidentals to wharf side, and 6s. for freight and marketing overseas (7). The minimum payable price is 10s. 6d. to 11s. 6d. per bushel in England, to which must be added 3s. in Germany, or the import duty rate

applying in other European countries. The average price for Australian apples as a whole in England was about 10s. in 1928, and under 10s. in 1930. Nevertheless, the bulk of the main export varieties from Western Australia sold f.o.r. to European buyers at 7s. 3d. to 9s. per bushel in 1928, and 7s. 3d. to 8s. 6d. in 1930, equivalent to about 13s. 9d. to 15s. 6d. per bushel in England.

Estimating the 1930 crop at 10,000,000 bushels (the estimate is made up as follows:—Tasmania, 3,700,000; South Australia, 1,250,000; Victoria, 3,300,000; New South Wales, 1,250,000; Queensland, 100,000; and Western Australia, 400,000 bushels), and assuming an average consumption in Australia of three-quarters of a bushel per head of population, Table 1 indicates the average surplus or deficiency over local requirements during the past four seasons.

TABLE 1.—AVERAGE AUSTRALIA APPLE PRODUCTION AND CONSUMPTION (IN THOUSANDS OF BUSHELS) FOR SEASONS 1926-27 TO 1929-30.

State.	Yield.	Estimated Consumption.	Surplus or Deficit.
Tasmania	3,400	150	+ 3,250
Victoria	2,100	1,400	+ 700
South Australia	850	450	+ 400
Western Australia	700	300	+ 400
New South Wales	900	1,850	— 950
Queensland	130	650	— 520
Commonwealth	8,080	4,800	+ 3,280

During the same period, the export averaged 3,000,000 bushels, or only 280,000 less than the average surplus. When the individual years are considered (see Figure 1), it will be seen that Australia has ranged from a surplus of 2,375,000 bushels to a shortage of 1,050,000 bushels. Table 2 shows the variation from the average yield in the principal apple-growing States.

TABLE 2.—VARIATIONS (IN THOUSANDS OF BUSHELS) FROM AVERAGE YIELD IN PRINCIPAL APPLE-GROWING STATES.

——	1926–7.	1927–8.	1928–9.	1929–30.
Tasmania	— 475	+ 1,325	— 1,075	+ 225
Victoria	— 1,600	+ 1,600	— 1,500	+ 1,500
South Australia	— 450	+ 500	— 400	+ 350
Western Australia	+ 200	— 300	+ 400	— 300

Though overseas prices are affected by other conditions as well as the supply of Australian fruit, the heavy export from Tasmania, Victoria, and South Australia in 1928 and 1930 coincided with low-price periods. 1930 was a particularly unfortunate season, as the prices were never high, and the market collapsed during the third week of June owing to an early spring in Europe, accompanied by a glut of soft fruits. In previous seasons, prices have usually been maintained through July. In 1927 and 1929, Tasmania and Western

Australia benefited from relatively high prices both in Australia and overseas. It is evident that the condition of the industry in the several States requires individual examination.

Queensland.—Owing to its geographical position, suitable apple land is limited, and the State is unlikely to become an exporter of apples.

New South Wales.—Local production is still below requirements. This has led to a rapid increase in the planted area during recent years. A marked annual fluctuation of the crops has developed, the large crops coinciding with those of Tasmania, Victoria, and South Australia. Local storage of apples has not yet been developed on sufficient scale to prevent temporary gluts at the height of the season in heavy-crop years. This will probably become more serious if the fluctuation continues, and may force this State to develop an export trade. Up to the present, the latter has been small.

Victoria.—The annual crop fluctuations have been very marked in recent years, production having varied from less than one-half to over two and one-half times normal local requirements. In consequence, the State has been alternately importing and exporting apples. The price obtained for export fruit in recent years has only averaged about 10s. or less, against an average cost of growing and marketing of about 11s. 6d. Low prices in 1928 and 1930 in the local market were a result of an excess over requirements of upwards of 1,000,000 bushels, although exports totalled approximately 1,000,000 bushels.

Tasmania.—Crop fluctuations are less marked in this than in the other States. The mainland, especially in New South Wales, provides the main market for apples, the export trade being used to absorb the surplus as far as possible. In heavy-crop years, the mainland market is reduced in value owing to large local supplies, and Tasmania is forced to export a larger proportion of its production. The planted area is declining unevenly, a result of poor results in the heavy-crop years alternating with profitable returns in the light years.

South Australia.—The condition of the industry in this State is similar to that in Victoria. The crop is now varying from below to about three times local requirements. Marked fluctuations in production have been the rule. Practically no Australian market outside its borders is available in heavy-crop years, so that the State is forced to export. Large surpluses resulted in poor local prices in 1928 and 1930. The planted area is declining steadily.

Western Australia.—The conditions in this State are quite different from those in the other States. The annual production fluctuates from about one-third over local requirements to nearly three times as much. The heavy-crop years have coincided with the light years of the other States. The crop has always been large enough to allow of an export trade varying between 160,000 and 650,000 bushels each year. This export fluctuation is much less than that from Victoria and South Australia. The quantity exported is relatively small, and is in better demand than the fruit from the other States. Lastly, owing to the presence of codlin moth elsewhere, no apples from outside are allowed into Western Australia. These facts guarantee to the local grower reasonable prices for good fruit both in light and heavy years. In the heavy years, the shortage in the eastern States has provided a good

market for the surplus of the varieties which are too late for the main export trade. The present conditions are very favorable to Western Australian growers, and the planted area is increasing steadily.

All States.—Summing up, it would appear that the conditions prevailing in recent years, and particularly since 1926, have been profitable to the industry in New South Wales and Western Australia, unprofitable to Tasmania in alternate years, and generally unprofitable in Victoria, South Australia, and in the Commonwealth as a whole. The principal factor operating to this result has been the existing alternation of large and small crops in the several States.

3. Crop Fluctuations and the Need for their Investigation.

If, as concluded above, the existing crop fluctuations are the principal bar to prosperity in the apple-growing industry, it becomes clear that there is an essential need for investigation into their cause, and the possibility of their control and prevention. It is admitted that nature may again, as it did in the past (Fig. 3), correct the fluctuation. However, we do not know how long we must wait for this, and we do know that even should the trouble disappear, it will surely re-appear again unless we can interfere. This article is written in the hope that it will stimulate investigations and experiments throughout the apple-growing areas, thus providing variety of attack and variety of conditions, on a scale large enough to test the commercial possibilities of the methods. Little can be done in the States most concerned until the spring of 1931, as the crops of 1930-31 will certainly be small in Victoria, New South Wales, and South Australia, and below mean in Tasmania.

4. The Origin of Crop Fluctuations.

That apple trees tend individually to carry crops above and below their mean in alternate years is a well-known horticultural fact. In some varieties, e.g., Dunns, it is so marked that they are recognized as alternate year croppers. In others, the fluctuation is normally so small that they are regarded as regular croppers. The habit of alternate year heavy and light cropping normally becomes evident only after the trees have reached the condition usually known as "full-bearing." The tendency is for orchards over any large area to produce approximately average crops. This is due to the fact that planting is usually spread over a number of years, resulting in approximately equal numbers of trees bearing individually above and below mean crops in the same year. Wherever apples are grown extensively in Australia, something eventually happens, however, which prevents the normal setting in some season, causing the majority of the trees to carry little or no crop. This is usually followed by the majority carrying a heavy to very heavy crop the next season. Alternate heavy and light cropping over the area as a whole is then set up until factors, like the coming into bearing of young trees, reduce the amount of variation. Cropping tends to work back slowly towards normal until it is again upset by a recurrence of something which affects setting.

Australia differs from other apple-growing countries, in respect to crop fluctuations, mainly in the extraordinary range of the variations

in recent years. Fluctuations of 15 to 20 per cent. above and below the mean are not uncommon elsewhere, notably in some Western American States, such as Oregon, California, and Washington. The Victorian fluctuation of 70 per cent. above and below the mean of recent years shows how great it may be in Australia.

The principal factor in Australia appears to be occasional State-wide thrips infestation of the blossoms. Over more limited areas, late frosts may have a similar result. Once the fruit is well set, factors which cause them to fall have little effect in this direction. The main effect comes from the destruction of the blossoms.

The Victorian crop failure in 1927, and that in Western Australia in 1928, were both attributed by growers to thrips at the blossom time. It is considered that this was true in the Victorian case, and partly true in Western Australia. A similar explanation was given by growers in the latter State for the small crops in 1916 and 1926. In all the cases mentioned, infestation of the blossoms was recorded.

After a small crop, one as much above the mean as the former was below can be expected, subject to normal setting in the spring. This statement, of course, applies to commercial orchards, and not necessarily to all individual trees. Some trees may fail to carry a good crop for reasons applying specifically to them, and which are not general. In mass fluctuations, the trees vary from the normal for commercial orchards only in their bearing, and this is mainly the result of an alternate scarcity and ample supply of fruit buds. After the large crop comes a small, and the alternation sets in. Providing conditions remain normal, the swing of the fluctuation tends to narrow until average crops are again obtained. This up and down swing of the crops provides a basis for predicting future crops. Tables 2 to 5 show the yield in bushels of the principal apple-exporting States since the 1913-14 season. The bushel weight for any variety does not vary greatly, and the figures, therefore, give an approximate indication of the weight of the crops. The tables also show the estimated normal crop, i.e., the crop which would have occurred if fluctuations had not started. The normal crop is calculated from the mean of a group of crops, allowing for increases due to the age of the trees and varying bearing area. It is based upon the assumption that all departures from the normal tend to balance each other. To obtain the estimate of the coming crop, the amount by which the last crop differed from the normal is added to or deducted from the normal of the next year. Thus the 1928-29 crop in Tasmania was 1,100,000 bushels below normal, the 1929-30 crop should be much above or about 4,500,000 bushels. In the same way, the Victorian 1930 crop should be about 3,400,000 bushels, the South Australian 1,350,000 bushels, and the Western Australian 430,000 bushels.* It is not intended that such estimates should be relied upon too closely, as it is essential that they should be modified, if necessary, after the setting of the fruit in October and November is known. If the setting and rainfall are normal, it is believed that the estimate may be adopted as reasonably correct. If thrips or frosts affect the setting, or the spring and early summer is unusually dry, the

* The official 1930 figures are—Tasmania, 4,000,000; Victoria, 2,800,000; South Australia, 1,250,000; and Western Australia, 440,000 bushels.

estimate must be reduced accordingly. Correcting the above figures for the 1929-30 crops on the basis of published reports on setting, rough estimates may be made of the 1930-31 crops as under:—

—	1929-30. (Estimate).	1930-31. (Prediction).
Tasmania	3,700,000 bushels	2,900,000 bushels
Victoria	3,300,000 ,,	800,000 ,,
South Australia	1,250,000 ,,	600,000 ,,
Western Australia	400,000 ,,	1,200,000 ,,

The probable importance of early crop estimates will be referred to again. The accuracy of the graphs in respect to the normal crop probably varies somewhat. It is probably closest to accuracy in reference to Western Australia, and least in respect to Victoria, as the bearing area is not known for the years before 1921 for that State. The graphs indicate that the fictuations invariably commence with a crop below expectations. The variation may be further increased by the coincidence of an anti-setting factor and a low-crop year. The following table shows the principal unexpectedly low crops and their approximate deficiency as compared with the expected crop:—

Table 3.—Unexpectedly Small Crops (1914-1929) and Deficiency as Per Cent. Estimated Crop.

—	New South Wales.	Victoria.	Tasmania.	South Australia.	Western Australia.
1914-5	..	74	..	51	..
1915-6	..	..	..	..	40
1916-7	..	..	12	..	..
1917-8	..	..	37	36	..
1918-9	..	..	..	37	..
1919-20..	26	..	..	26	..
1921-2	..	..	..	..	17
1923-4	24	..	27	..	..
1924-5	..	..	45	..	..
1925-6	..	..	..	..	17
1926-7	41	77	..	63	..
1927-8	..	..	..	..	33

Mr. J. W. Evans, Division of Economic Entomology, has informed me that bad thrips infestation of the apple blossoms was recorded in New South Wales 1926-27, in Victoria 1914-15 and 1926-27, and in Western Australia in 1915-16, 1926-26, 1927-28. No records are known from Tasmania or South Australia.

The physiological explanation of the alternation of heavy and light crops is probably to be found in the carbohydrate-nitrogen ratio (2, 3, 6). Heavy crops are associated with a leaf area below and light crops with one above that developed with average crops. In other words, fruit production and vegetative growth, especially of the spurs, are inversely related. Investigations have shown that the leaf area on the spurs is definitely related to bud formation and fruit setting (4, 5). Increase of crop is limited, not only by the size of the tree,

but by the amount of foliage, for below a certain amount per spur and per fruit the latter cannot develop normally. Chemical investigations have shown that the greatest demand on the trees for nitrogen is during the blossoming and fruit-setting period, and of carbohydrates from then on until the fruit is practically full grown (1).

Nitrogen is obtained by the roots, and is least available when the soil is cold, and most when it is warm and moist. The actual amount, of course, varies with the soil. Carbohydrates are formed by the leaves, and are stored in the tree. The greater the amount of foliage, the greater the accumulation of carbohydrates. Accepting these facts, the following outline shows how the carbohydrate-nitrogen theory may explain the origin of crop fluctuation. Let us assume that apple trees previously bearing approximately equal crops each year are prevented from setting fruit one spring. As a consequence, the nitrogen supplies which would have gone to the flowers and young fruits become available for vegetative growth, and the trees make strong growth with an above normal development of foliage. The accumulation of carbohydrates from the previous season, plus that produced by the foliage, not being drawn upon by the flowers and fruit, is, early in the season, present in the trees in excess in relation to the nitrogen which has not been so accumulated. This condition is favorable to fruit bud formation. The result is that when the spur buds are differentiated as fruit and growth buds, probably in December, the proportion of the former to the latter is high. As growth falls off in the late summer, nitrogen is also accumulated in the trees, but not sufficiently to affect the excess ratio of carbohydrates when the buds burst in the following spring. The opening of the flower buds makes a heavy demand on the nitrogen which continues as the fruit sets, and then falls off. Less nitrogen than the previous year is available for growth and it is consequently weaker. As the blossoms develop and the young fruits grow they draw more heavily on the carbohydrate stores and relatively less on the nitrogen; consequently when the buds are differentiated, the ratio of carbohydrates to nitrogen is also reduced. If setting has been normal, the crop of fruit is very heavy, and carbohydrate supplies become relatively low, while the reduced foliage results in reduced production. The conditions are then more favorable to leaf bud, rather than fruit bud, formation. Nitrogen is accumulated in the remainder of the growing season. In the following spring, the trees have relatively few fruit buds and a relative low ratio of carbohydrates to nitrogen. Consequently, the crop is small and the vegetative growth strong. The fluctuation then continues, modified by seasonal conditions such as unusually dry seasons which prevent normal leaf work, and reduce the demand for carbohydrates, the fruit being smaller than normal. A factor more or less preventing setting in the heavy blossom year may bring the trees back towards average cropping, or may even reverse the fluctuation. The reduction of the setting in a light blossom year will, of course, aggravate the existing trouble. It is clear that if the foregoing be true, that the only ways of upsetting an existing fluctuation are either to prevent very heavy setting, or to induce weaker growth and stronger setting in years of expected light crop by providing the tree with sufficient available nitrogen to balance up the excess of carbohydrates. The first method is undoubtedly the more reliable in operation. It has the objection, however, that it may clash with

natural factors preventing setting. The second method is more uncertain and requires careful testing under different conditions before it can be recommended. The time of application of nitrogen and its effect on the keeping quality of the fruit must be studied.

Numerous cases of the effect of the destruction of blossoms by frost in one season causing heavy cropping in the next, must be known to all experienced growers.

5. The Desirable Cropping System.

There is no doubt whatever that Australia, as a whole, would profit if the crops varied little from the mean. The average of 8,000,000 bushels of recent years would permit an export of approximately 3,000,000, after allowing for local requirements. This figure would be well above the minimum and well below the maximum export of recent years. Such a system of cropping would prevent gluts and help to stabilize prices in Australia. It would stabilize exports, and allow that side of the industry to be organized efficiently.

Before the problem of how to secure average crops can be attacked, it is necessary to determine their desirable constitution. There are three possible methods of securing the result. In the first place, it might be obtained by deliberately interfering with the setting of the Victorian crop in the spring of 1931, so that the 1932 crop is reduced to about that of the 1928-29 season. For obvious reasons, this method is impracticable unless nature intervenes to that end. The effect would be to secure a heavy crop in 1933 which would balance the light crops of New South Wales, Tasmania, and South Australia in that year. Table 4 shows what would have happened had the Victorian crops of 1927-28 and 1928-29 been reversed.

Table 4.—Effect of Transporting Victorian Crops of 1927-28 and 1928-29.

	1927-28.	1928-29.
	Bushels.	Bushels.
Queensland	104,000	183,000
New South Wales	1,254,000	640,000
Victoria	3,712,000	626,000
Tasmania	4,673,000	2,292,000
South Australia	1,352,000	447,000
West Australia	409,000	1,122,000
Actually	11,504,000	5,310,000
Commonwealth, if Victoria crop transposed	8,418,000	8,396,000

Secondly, average crops might be secured if the majority of trees could be induced to produce individual average crops. The difficulties in obtaining this result would be very great, as this method of fruiting is against the normal habit of apple trees. It appears not only to be impracticable, but also, if obtained, to offer less advantages than the next method.

The last and most promising cropping system would be to have approximately one half the trees of each variety in each State in heavy bearing in alternate years. This would produce average crops, the bulk of which would come from one half the trees. The fruit from the light-crop trees would have to be sent directly to the local market,

as its keeping quality would not be high. That from the heavy-crop trees would furnish the export and storage quota for, within reasonable limits, keeping quality, colour and quality generally increase with the size of the crop. This method would conform to the habit of the trees, and would also simplify picking.

It cannot be recommended that steps should be taken to bring about this system of half-and-half bearing immediately, as it must always be remembered that the expected result may be upset by thrips or some other factor affecting setting. If, however, a start could be made in 1931 with, say, 10 per cent. of the trees in New South Wales, Tasmania, Victoria, and South Australia, it would be a move in the right direction, which, if successful, would then progress more rapidly. Tasmania is, apparently, approaching a series of medium crop years, and consequently growers may be disinclined to act. Nevertheless, Tasmania stands to gain immediately by a marked increase in the crops in the odd years, which are its most profitable seasons under present conditions. As Western Australian growers benefit by the existing fluctuation, they are less interested in the matter. Nevertheless, they are always faced with the possibility of having their heavy crops thrown into competition with heavy crops in the other States as a result of an upsetting of the present fluctuation.*

The most economical method of preventing a heavy crop is still to be worked out. Pruning does not seem a satisfactory means as the prevention of setting must be obtained without reducing the spur system below normal limits. Removal of the fruit cannot be recommended, as the loss of nitrogen which it is desired to prevent will have already taken place. This also explains why thinning as ordinarily practised has little effect in securing regular cropping. Destruction of the unopened flowers appears to be the most desirable aim (4). Removal by hand is certainly the most efficient method, but is expensive.

A spray (preferably a fungicide) which would kill the flower buds and yet not damage the tree appears to be the most economically desirable method. Experiments are necessary to ascertain the best spray and the strengths at which it might be used. It is essential that at least 95 per cent. of the blossoms be destroyed, as a 10 per cent. set will produce a good crop. If a spray be used, it should be applied when the bulk of the blossoms are in the pink. The late blossoms would set some fruit, but probably much of it would be russetted by the spray.

In respect to the possible effective use of fertilisers, it is suggested that tests be made with heavy dressings of nitrogen in the autumn preceding an expected light crop. In the alternate years, nitrogen might be tried after settling. If the blossom has been removed, normal manuring should be adhered to. At present, pending the discovery of more effective method, the removal of the blossoms by hand is advised. This, of course, should be regarded as a test, and it is suggested that it be applied to a minimum of ten trees.

If, as stated, thrips are an important and probably the most important cause of crop fluctuations, investigations are desirable to ascertain effective means of controlling them and thus of reducing the likelihood of the recurrence of fluctuations after they have been eliminated.†

* Thrips in 1930 caused a loss of approximately one-third of the crop in Western Australia. Average crops may now be expected.

† These are in hand. See this *Journal*, Vol. 3, p. 239.

6. The Value of Early Crop Estimates.

As refrigerated shipping space for the apple export has to be chartered by November and early December, it is highly desirable to know what the surplus over Australian requirements is likely to be. A still more difficult matter is to decide the dates on which the earliest consignments are to be lifted. Until this can be done with reasonable accuracy, we shall either continue to have immature fruit submitted for export from boats being too early, and even possibly over-mature fruit if they are too late. The problem is an important one. An important observation has been made during the past three seasons, namely, that there appears to be a very direct relation between the size of a crop and the date at which the principal export varieties mature sufficiently for shipment. There has been a difference of about three weeks between the maturing dates of the main crop of export varieties in Western Australia in very heavy and very light crop years. The heavy crops are late and the light crops early as compared with medium crops. This conclusion is extremely important, if true, taken in conjunction with the method of crop forecasting already given. Given a reasonably accurate forecast in November, it should be possible to determine approximately the most desirable date of shipping specific varieties. Undoubtedly this association of size and maturity of crop has held during the last three seasons in Western Australia, during which there were two very light crops and one very large one. There is certainly sufficient evidence to warrant further investigations. The data in Western Australia were obtained in the following way:—Observations were made of the maturity of the fruit shipped overseas in the different years, using both the ground colour and the iodine test. Tests were also made on the crop of four main varieties on the same group of trees each season. The conclusion was arrived at that in the light-crop years (1927-28 and 1929-30) the best picking period in Western Australia for the variety Cleopatra was about the first week of March, and the fourth week of March in the very heavy year (1928-29), with Dunns one week and Jonathans two weeks earlier in each case.

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Caseous Lymphadenitis.

The Association of the Bacillus of Preisz-Nocard with Lesions caused by *Oesophagostomum columbianum* in Sheep.

By H. R. Carne, B.V.Sc., Lecturer in Veterinary Pathology and Bacteriology, University of Sydney, and I. Clunies Ross, D.V.Sc., Parasitologist, Commonwealth Council for Scientific and Industrial Research.

1. Introduction.

It has been suggested that the occurrence of caseous lymphadenitis in Australian sheep may be associated with infestation by the larval form of *Oesophagostomum columbianum,* the injuries caused by this parasite in the bowel wall serving as portals of entry for the bacillus of Preisz-Nocard. Recently, an officer of the Commonwealth Department, Markets and Transport (Meat Inspection Branch), has noted the occurrence of lesions, which he took to be those of caseous lymphadenitis, in 8 to 10% of the ischiatic glands of two lots of sheep heavily infested with oesophagostomiasis. The opinion was, however, expressed by one of us (H. R. C.) that these gland lesions were due to wandering *O. columbianum* larvae and not to *B. Preisz-Nocard,* this opinion being based on the results of bacteriological examination from time to time of a considerable number of nodules of *O. columbianum* in lymph glands, in only two of which were any organisms detected, these being Gram-negative bacilli of the colon-typhoid group. One of us (H. R. C.) has also found that the greenish coloration of pus in sheep is not a specific character of lesions due to *B. Preisz-Nocard,* but is common in suppurative conditions of sheep caused by other organisms. It is noteworthy, however, that certain Continental workers claim that ingestion is the common method of infection with *B. Preisz-Nocard,* and Carré (1928) attributes to intestinal parasites a very important role in facilitating this infection by producing injuries of the mucosa of the alimentary canal, which serve as portals of entry for *B. Priesz-Nocard.* Should the larvae of *O. columbianum* play some part in bringing about infection with caseous lymphadenitis through the wall of the alimentary canal, it would add a serious complicating factor to the problem of the control of caseous lymphadenitis. It was decided, therefore, to investigate this point.

2. Experimental Details.

Animals Used.—Nine lambs, four months old, which were unshorn but which had been tailed and castrated, and had come from one property, were selected for the experiment. Throughout the experiment, which lasted 51 days, all the animals were run together in a yard with a brick floor, and were hand fed.

Method of Infection.—Five of the lambs were given a large dose (10^{-2} gm.) of freshly prepared culture of *B. Preisz-Nocard* on two successive days, the dose being administered in 10cc. normal saline by syringe per os. This was followed on the second day by approximately 1,500 larvae of *O. columbianum* and a certain number of other infective larvae (*Haemonchus contortus, Ostertagia circumcincta,* and *Trichostrongylus spp.*). A fortnight later, three of these lambs received a further larger dose (4×10^{-2} gm.) of *B. Preisz-Nocard* and an additional 500 larvae of *O. columbianum.*

Two of the four remaining sheep received two doses (10^{-2} gm.) of culture on successive days, and one of these, fourteen days later, a third dose (4×10^{-2} gm.) of culture.

The remaining two sheep (larval controls) received 1,500 *O. columbianum* larvae but no *B. Preisz-Nocard* culture. These details are shown in Table I.

TABLE I.

Sheep No.	*Preisz-Nocard Culture.*			Total.	*Oesophagostomum. Larvae.*		Total.
	15.9.30. gm.	16.9.30. gm.	29.9.30. gm.	gm.	16.9.30.	29.9.30.	
70 ..	10^{-2}	10^{-2}	4×10^{-2}	6×10^{-2}	1,500	500	2,000
67 ..	10^{-2}	10^{-2}	4×10^{-2}	6×10^{-2}	1,500	500	2,000
65 ..	10^{-2}	10^{-2}	4×10^{-2}	6×10^{-2}	1,500	500	2,000
64 ..	10^{-2}	10^{-2}	..	2×10^{-2}	1,500	..	1,500
68 ..	10^{-2}	10^{-2}	..	2×10^{-2}	1,500	..	1,500
66 ..	10^{-2}	10^{-2}	4×10^{-2}	6×10^{-2}	..	..	..
63 ..	10^{-2}	10^{-2}	..	2×10^{-2}	..	..	..
69 ..	..	..	..	..	1,500	..	1,500
71 ..	..	..	..	..	1,500	..	1,500

The culture of *B. Preisz-Nocard* was tested for pathogenicity on two sheep, one of which received 10^{-2} gm., intravenously, and one 10^{-2} gm. subcutaneously.

3. Results of Post Mortem Examinations.

The sheep were killed from 37 to 51 days after the commencement of the experiment. All sheep showed some degree of infestation with stomach worms (*Haemonchus contortus, Ostertagia circumcincta,* and *Trichostrongylus spp.*), and all, with the exception of one of the culture controls (63), showed lesions of larval oesophagostomiasis. The other culture control (66) showed few lesions in the bowel wall, compared with the other sheep drenched with larvae, and the lesions present appeared to be those of an older and earlier infestation, none of them containing fourth stage larvae. In the seven sheep receiving *O. columbianum* larvae, young bowel lesions were numerous and 24-60% contained fourth stage larvae.

All the important lymphatic glands were carefully examined, and particularly those draining the intestines, these being subjected to careful bacteriological and histological examination. The results may be summarized as follows:—

> In the five test sheep receiving *B. Preisz-Nocard* culture and *O. columbianum* larvae, two showed lesions in submaxillary glands, and one lesions in the mesenteric and right prescapular gland, due to the *B. Preisz-Nocard,* and four showed lesions in the mesenteric or colic glands due to *Oesophagostomum.* Of the culture controls, one showed a lesion in the right submaxillary gland, due to *B. Preisz-Nocard,* but neither showed lesions in the lymphatic glands due to *Oesophagostomum* larvae.
>
> Of the two larval controls, neither showed lesions due to *B. Preisz-Nocard,* but one showed lesions of *Oesophagostomum* in the colic, rectal, and ischiatic glands.

Of the 69 nodules of *O. columbianum* from the several sheep which were examined culturally, 27 (39%) were sterile, while the remainder contained varying organisms, as follows:—

Diphtheroid bacilli	in 16 nodules
Cocci	in 15 nodules
Gram Positive bacilli	in 10 nodules
Hyphomycetes	in 5 nodules
Gram Positive Strepto-bacilli	in 2 nodules
Actinomycosis	in 1 nodule

No nodules contained *B. Preisz-Nocard.*

Three sheep, two of which received culture and larvae, and one larvae only, showed greenish lesions about 0.5cm. in diameter in the liver, the histological picture in all these being that of eosinophilic abscess formation characteristic of lesions caused by larvae of *Oesophagostomum.*

4. Discussion.

It is seen that in all sheep receiving *Oesophagostomum* larvae a heavy infestation of the bowel wall was set up, while five of these sheep received simultaneously a much larger dose of *B. Preisz-Nocard* than would be likely to occur under natural conditions. Thus, if injury to the bowel wall by parasites could serve as portals of entry for the Preisz-Nocard bacillus, optimum conditions were here created. It was found, however, that lesions of caseous lymphadenitis occurred in only three of the five test sheep, and only in one of these were the lesions in a gland draining the intestinal tract in which the injuries caused by the parasites were present. That lesions occurred in the submaxillary gland in two of the test sheep and in one culture control, while the larval controls were free from lesions of caseous lymphadenitis, suggests that infection in these cases resulted from the organisms administered *per os,* possibly taking place through injuries to the buccal mucous membrane caused by teething. In the one test sheep which showed lesions due to *B. Preisz-Nocard* in a mesenteric gland, there is strong presumptive evidence that infection took place through the damaged bowel wall. This sheep was one of the two test sheep receiving the smaller dose of culture, 10^{-2} gm.

While it is thus possible that under exceptional circumstances bowel injuries due to *Oesophagostomum* larvae might facilitate infection with *B. Preisz-Nocard* via the alimentary tract, the results tend to support the observations of other workers in Australia, that whereas lesions in the alimentary tract caused by parasites are exceptionally common, primary lesions of caseous lymphadenitis in glands draining the alimentary tract are very rare. On the other hand, the experiment showed that lesions in lymphatic glands draining the alimentary tract are frequently caused by *Oesophagostomum* larvae, and such lesions are very similar macroscopically to those of caseous lymphadenitis, for which they may be easily mistaken on ordinary post-mortem inspection.

It does not appear that *Oesophagostomum* infestation need be considered as an important complicating factor in any scheme for the control of caseous lymphadenitis.

The Drying of Thin Timber Case Stock.

The Division of Forest Products of this Council is responsible for the short article that follows. In forwarding it on for publication the Chief of the Division (Mr. I. H. Boas) stated:—" While the experiments upon which the information contained in the article is based are by no means complete, the results show such promise that it has been thought advisable to circulate them among sawmillers without delay. In the present state of the sawmilling industry many millers are devoting their attention to the possibilities of the case market, and there can be no doubt of the ability of our hardwoods to meet the requirements of casemakers if suitably treated. Although this article refers specifically to certain of the less dense eucalypts, the results may have a much wider application."—Ed.

It has long been the dream of almost every sawmiller cutting the light eucalypts, commonly known as red or Alpine ash in New South Wales, red ash, mountain ash, and messmate in Victoria, and the various timbers, loosely classed as Tasmanian oak, to use these timbers for case stock on an extensive scale. Certainly, these woods are used on occasions for cases, and in this use have some undoubted advantages, but the case-cutting proposition is rarely an attractive one, due to certain apparent disabilities of the timber. The worst of these faults can be traced to the lack of seasoning or to drying defects; the solution to the problem undoubtedly lies in cheap and effective seasoning. Thus, when made from green timber, the hardwood case has the faults of shrinkage, warping, splitting at the nails, excessive weight, staining of contents, and unattractive appearance. All but one of these disadvantages can be removed by proper seasoning treatment, and that one, the factor of excessive weight, can be reduced to a negligible amount in the light hardwoods when treated by the reconditioning process.

The common method of seasoning thin case stock is to dry the timber in approximately 1-in. thicknesses, and to re-cut, after drying, to the thinner section. With softwoods, where case timber can be obtained in this way without seriously affecting the recovery from the log, and where the drying time for 1-in. case stock is only a matter of a few days, such a process is feasible. In the case of Australian hardwoods, however, it is often desirable to obtain the case material from the log in the thin sections, in order to increase the recovery of clear stock. The drying of 1-in. Australian material is also a comparatively difficult and lengthy matter, so that in the majority of instances in this country the treatment of 1-in. stock for cases is far too costly a method to be commercially practicable. Air seasoning of the thin sections is not uncommon, but such a procedure is usually attended by excessive shrinkage and warping, due largely to collapse.

From time to time, however, isolated experiments on the air or kiln seasoning of thin case stock, followed by the reconditioning treatment for the removal of collapse and warping, have been carried out by sawmillers, and the results have been encouraging. As a result of an inquiry relative to kiln design, from a sawmiller who had been interested in one of these tests, the Forest Products Division recently carried out a series of tests on the kiln drying of thin case stock.

For these tests, the small laboratory kiln at the head-quarters of the Division, in East Melbourne, was used. In the first test, ¼-in. green mountain ash was successfully dried to a moisture content of

12 per cent. in sixteen hours. At the completion of the drying, the stock was severely warped, and collapsed, but was free from cracking. The timber was then subjected to a reconditioning treatment, consisting of two hours' steaming at 212 deg. F., and it was then left to cool in the air. At the end of this treatment the stock was well dried and was free from collapse, warping, or checking. It was attractive in appearance, and was quite suitable for dressing if this had been required.

Further tests were made, until finally ¼-in. stock was dried in the experimental kiln in ten hours. After reconditioning, this stock was free from blemish, with the exception of isolated small end checks in one or two of the pieces.

Acting on a suggestion that it would be more economical if the timber could be dressed green and then kiln dried and reconditioned, a charge of stock dressed green was so treated. This resulted in an excellent product, the only blemish being slight stain where the spacing strips came in contact with the boards during reconditioning. This could be reduced to a negligible extent, if not entirely eliminated, by care in the selection and handling of spacing strips.

That green dressed stock can be satisfactorily dried is a fact of much importance, because handling and machinery costs are thereby considerably reduced.

The results of these tests in the experimental kiln and reconditioning chamber indicate that the kiln drying of thin case stock is quite an attractive proposition from the commercial point of view. It is certain that with a suitable design of kiln, ¼-in. case sides, tops, and bottoms can be thoroughly dried in 24 hours or less, with the addition of a further two or three hours' treatment for reconditioning.

It must be remembered that reconditioned case stock is by far a superior product to dry but untreated stock made from these timbers. In addition to being better in appearance, it is softer, far less brittle, and has not the same tendency towards splitting during nailing. In fact, reconditioned hardwood is probably as good as, if not better than, many softwoods of the same moisture content in its resistance to splitting by nails.

In the Division's tests mentioned above all the drying was carried out at a temperature of 180 deg. F., and it was found that the timber was particularly tolerant to such severe drying conditions. This indicates that the most important factor in kiln design for this material is good air circulation.

The Division has had under consideration the question of the selection of a suitable type of kiln for this class of material. A progressive kiln has been designed, and is at present being erected by a sawmiller. When this kiln is in operation, the details of its performance will be circulated. In the meantime, the Division will be glad to give further information or technical assistance in connexion with this problem to any one interested.

Report on the Soils of the Bed of Lake Albert, South Australia.

By J. K. Taylor, B.A., M.Sc., and H. G. Poole, M.Sc.

The survey of the bed of Lake Albert was undertaken by the Council's Division of Soil Research as a result of a request from the South Australian Parliamentary Standing Committee on Public Works, acting in conjunction with the Development and Migration Commission of the Commonwealth, that the Chief of the Division of Soil Research should co-operate with the Director of Agriculture of South Australia in reporting upon the type, quality, and suitability of the soil in Lake Albert for dry farming, or for production under irrigation. The present communication is an account of the survey, its technique, and scientific results. The point of practical importance in the report is that the work of the Division has demonstrated that the area examined would be little suited for agricultural purposes, and thus that a drainage scheme, estimated to cost many thousands of pounds sterling, would be quite unwarranted. In other words, the expenditure of the inappreciable sum involved in the Division's operations, together with the application of recently developed methods of soil examination, have shown the way to the avoidance of what might otherwise have been a costly mistake in land settlement.—Ed.

1. Introduction.

Lake Albert is a relatively large body of water at the mouth of the River Murray, connected to Lake Alexandrina by the Albert Passage, which is about 20 miles south of the entrance of the Murray River into the larger lake. Three miles from Point Malcolm, at the western entrance to the passage, the lake broadens out into an irregularly shaped area of 36,000 acres, approximately 10 miles long and 6 miles across. It has several notable natural features, particularly the bold headland ending in Rumply Point, with a deeply scooped bay on the north and south sides, and the lagoonal extension at the south end, representing the remains of the ancient river channel when it passed through the lake to enter the Coorong. On the north-eastern and on the Warringee and Campbell Park headlands are steep limestone hills or cliffs, while on the remaining portions the ground slopes gently down to the shore line, and doubtless suffered some inundation when the Murray River came down in flood.

The waters of the lake are slightly saline; the salinity varies with seasonal conditions, and has an important bearing on the value of the lake as a source of stock water.

At the time of the survey, March-April, 1930, the lake level was very low owing to the continued low state of the river, and considerable areas were uncovered, particularly on the western side of the lake, where the shore line shelves gradually. The water, moreover, was affected by incoming sea water from Lake Alexandrina, which had become very saline as a further consequence of the low river level, so that Lake Albert water was not potable for humans and taken unwillingly by stock until accustomed to it. In the autumn of 1930, the lake had reached the lowest and poorest condition for many years, and appeared in a more unfavorable light than would usually be the case.

The reclamation proposal has been put forward a number of times during the last 30 years. In 1902, a series of preliminary investigations were begun on the control and development of the Lower Murray River, the lakes, and the delta. It was proposed to build a series of barrages across all but one or two of the outlets of the delta sufficient to prevent the ingress of all salt water with the wind and tide, and on the selected channels a barrage up to the level of the low-water mark. Lake Alexandrina being so controlled, the sea water could have no effect on it, and it would be maintained permanently in a fresh condition. The proposal was allied with the scheme to make the Murray River navigable to small shipping, with a sea port at the Murray mouth. In 1904, it was suggested as a definite plan to include the drainage of Lake Albert with the construction of the tidal barrage, with the twin objects of opening a supposedly rich area to closer settlement, and with the money obtained from it recoup the outlay on the drainage scheme and assist the major proposition.

In recent times, the question of a barrage across the river has come up for further discussion owing to low-river levels allowing salt water to penetrate as far north as Mypolonga, while both lakes have been decidedly brackish. The sites investigated were the estuary of the river as it passes into Lake Alexandrina and the line between Point Sturt and Point Macleay in the same lake. In the event of the latter position being decided on, Lake Albert would be assured of a permanent gravity supply of fresh water.

The reclamation project was discussed first without considering the fundamental features on the agricultural side. The scheme appeared excellent on paper, as the engineering difficulties were regarded, rightly or wrongly, as easy of solution, and the water could be supplied for irrigation at a nominal cost. A report was obtained on a few samples in 1904 taken from various parts of the lake to a depth of several feet. Only lime and phosphoric acid were estimated on these samples, which were condemned without further analysis. A report later in the same year on other samples taken from the shore and in five places from the lake mud to a shallow depth was supplied by the Secretary for Agriculture. A table of this data is given later (p. 92). The conclusions reached were very favorable, and probably owed their support to the mistaken idea that the lake mud and the soil of the Lower Murray swamps were identical in character. The figures obtained were undoubtedly good, though considerably lower than for the better swamp soils. Unfortunately, all the mud samples were taken to a depth of 12 inches only, and nearly half of this depth would be surface slime. They cannot be considered as typical of the soils of the lake bed, except on the assumption that the soils as a whole were as uniform as those of the swamps, or that the samples obtained were representative of the various soils constituting the lake bed. Thus, even if the samples accurately represent the quality of the soil at the spot from which they were taken, they may be of little worth in appraising the value of the whole area. The black colour of the surface mud, due to the presence of considerable amounts of ferrous sulphide, misleads the observer in the field into imagining the mud to be highly organic.

Local reports state that thick reed growth occupied Meningie Bay and the extreme southern end of the lake, and it is probable that the final disappearance coincided with the salty condition of the lake during the 1902 drought. At the present time, there is only a minor occurrence

of reeds near Warringee Point and Rumply Point. There is no trace of reed remains in the mud as far as the survey showed, and, in spite of their complete decomposition, the organic matter and nitrogen are not higher than in the muds from other parts of the lake which did not grow reeds in recent times. It is also locally reported that before the 1902 drought the growth of water weeds was relatively abundant.

The subject of reclamation was raised again in 1914, in 1920, and in 1929. No further samples were taken or reports made on the soils till the survey was carried out in March, 1930, by the Division of Soil Research, this survey forming a logical extension of the survey of the Lower Murray swamps then in progress.*

2. Methods Employed in the Survey.†

In the survey of the bed of a large body of water there are two difficulties to be overcome not encountered in soil surveying on land, namely, the accurate fixing of the position of the borings and the accurate sampling of the mud to any desired depth. The work was done almost entirely from a shallow draught launch, which was able in some places to approach to a distance of 5 chains from the shore line, but, on the average, a strip of a quarter to a half mile in width along the shore was disregarded. Since much of the shallow water was over shelving sand or rock, and the immediate shore line was examined subsequently on foot, the loss in detail is of minor importance.

A series of nine flag beacons were erected at various prominent points round the lake, and the position of five outstanding buildings determined, making a total of fourteen stations for triangulation purposes. Throughout the survey the bearings were taken with a prismatic compass on three or more of these stations, where visible, for every point at which a boring was made. While it was not practically possible to ensure complete accuracy in fixing the positions, the boundaries of soil varieties so fixed are thought to be reasonably exact. As the lake itself forms part of three Hundreds (Bonney, Malcolm, and Baker), considerable trouble was experienced in constructing a satisfactory outline map.

With the exception of some surface borings in sandy and stony bottoms, all the work was done with a modified Frankel type borer. The details of the large borer used for taking samples for analysis are shown in Fig. 1.‡ The overall length employed was 18 feet, which, allowing for the depth of the water, gave an effective range of 13 feet of mud. Certain features of the borer may be noted in the event of similar work being undertaken elsewhere.

The head of the borer was made of bar steel, in which a cavity was hollowed; one end was turned to a point to assist vertical penetration of the mud, and a thread tapped in the other to take the screwed end of the first section of the shaft. Two heads were used, the smaller one for survey work and the larger for taking samples for analysis. Both

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* C.S.I.R. Bulletin: "The Soil Survey of the Lower Murray River Swamps" (in preparation).

† The authors are indebted to the Irrigation and Drainage Commission, and particularly the Chief Surveyor, Mr. A. D. Smith, for assistance in constructing most of the base map and in fixing the position of the flag beacons on the shore line. The modified Frankel borer was constructed from specifications, by the Physics Workshop of the University of Adelaide.

‡ See plates facing page 124.

were considerably larger than the ordinary Frankel borer, and proved very satisfactory, although the larger one was too heavy for constant use. The dimensions of the borers used are given in Table 1.

TABLE 1.—DIMENSIONS AND CAPACITY OF FRANKEL TYPE BORERS.

Borer.	Length of head (inches).	Dimensions of cavity) (inches).	Dimensions of fin* (inches).	Approximate capacity (c.c.).
Small size (ordinary)..	6½	3.7 x 0.4 x 0.25	3.1 (1.9) x 0.9	7
Medium size ..	7	4.3 x 0.5 x 0.6	4.5 (3.1) x 1.0	22
Large size	8½	6·0 x 0·8 x 1·0	6·0 (5.0) x 1.25	60

* Figure in brackets is the outer edge of fin. The small size borer had a brass plate bolted to the fin to enlarge its bearing surface.

The work was done generally in soft mud, the upper 2 feet offering relatively little resistance and requiring a large fin on the sleeve of the head to ensure its opening and closing completely. The fin used in all three cases was effective, although a smaller one may have served equally well. On numerous occasions, with the large borer exact definition of strata in the mud was possible, even to the point of sampling the surface 3 inches of mud alone.

The 18-ft. length used in this survey is as long as two men can conveniently handle under average conditions. Even with care, the shaft is liable to bend at the joints, which are points of weakness, especially with the heavy head. The prong and socket connexion covered with a brass sleeve is not satisfactory, and a small bolt was put through to hold the union firm. The brass sleeves readily slip round and come free, and moreover are too soft to stand a direct bending strain.

The defects of the Frankel borer are the liability of the shaft becoming strained and the impossibility of penetrating any resistant layer. In one part of the lake, off the Campbell Park shore, a surface crust of sand, 3 to 6 inches thick, overlies a moderate depth of clay, and considerable difficulty was experienced in penetrating this layer. Where the immediate bottom was hard sand, a post-hole digger was used, but with it only a maximum depth of 12 inches could be reached. As rock is known to underlie the eastern side of the lake, it was unfortunate that no means were available to discover whether the sand on the western side has a shallow rock foundation.

In regard to the detail of the survey, 300 borings were made over the area shown on the map, excluding from consideration the Albert Passage, the north-eastern angle of the lake, the lagoon at the south end, and the bay behind Reedy Point. The borings were roughly one-third of a mile apart. The profiles taken for analysis were numbered from 1 to 16, and their locations are shown on the map.

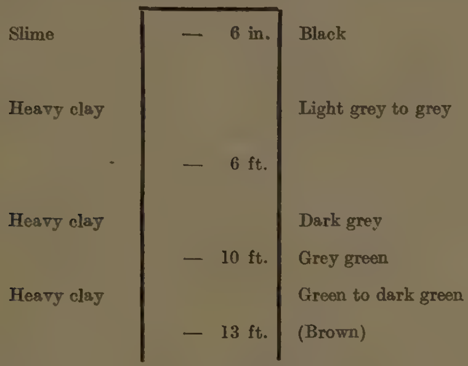
3. The Soils.

(*a*) *The Lake Bed.*—(Map, Fig. 4.)—The soils of the bed of Lake Albert have been grouped into seven classes, the divisions being in some cases arbitrary. The descriptions and areas are shown in Table 2.

TABLE 2.—DESCRIPTION AND EXTENT OF SOIL TYPES.

Soil Type.	Description.	Area.	Proportion of total area surveyed.
		acres.	per cent.
A	Deep uniform clay, more than 13 feet deep ..	10,000	29·5
B	10–13 feet of uniform clay over hard sandy bottom..	2,250	6·6
C	6–10 feet of uniform clay over hard sandy bottom ..	3,050	9·0
D	2–6 feet of uniform clay over hard sandy bottom ..	2,850	8·4
E	Less than 2 feet of clay over sandy bottom ..	10,200	30·0
F	Less than 2 feet of clay over limestone rock ..	3,250	9·5
G	2–6 feet of uniform clay over limestone rock ..	2,400	7·0
	Gross area surveyed	34,000	

The reason for the distinctive depths of the divisions is seen in the composition of the average profile of type A illustrated below:—



Average Profile of Type A.

The black surface slime was almost invariably present, with a few exceptions when surface hard sandy bottoms were found. It varied in amount from 1 to 6 inches thick, passing to a light-grey or grey heavy clay, slimy and soft at the top and with greater consistency below 2 feet. The colour changed to a dark-grey at about 6 feet, with a transition to grey-green about 10 feet, and through green to dark-green and sometimes brown at 13 feet. These colour changes are not constant, but they are sufficiently so for dividing the average profile, and are more definite in the wet than the air-dry state. Generally, the deep clay over sand (B) passes through the same colour range to the green clay, seldom to brown. Soil C usually ended in a dark-grey, or occasionally a green clay; while Soil D was grey throughout, and rarely a dark-grey. Soil E was never more than a slimy grey clay, and for reasons of shrinkage may be considered a surface sand, exactly as Soil F is virtually a surface rock. Soil G has one interesting feature not occurring in other profiles, in a layer of light-green calcareous sandy clay directly overlying the rock, and apparently not saturated with water. In describing the soils, it has been assumed that the sand or rock bottom is a limiting factor in the value of the soil.

The significance of the soil groups depends on a number of factors, such as the possible use to which the soil might be put on reclamation and drainage and salt problems. Generally speaking, the upper 6 to 8 feet of mud only can be considered from an agricultural stand-point, corresponding on drying to a 3 to 4-ft depth of soil. This shrinkage question reduces the apparent value of some soils of varieties D and G, and eliminates Soils E and F, or, in round figures, reduces the effective irrigation area by 50 per cent. Certain parts of the lake not examined alter this figure. The bay at the north-eastern corner falls into classes F and G, but a considerable portion of the southern extension, the Albert Passage, and the Reedy Point area are probably moderately deep or deep clays (A, B, or C). The area excluded is, however, sufficiently large to weigh seriously in the consideration of reclamation.

Two cross-sections of the bed of Lake Albert (Fig. 2) illustrate the profile sequence based on a representative series of borings. There is a solid bar of sand or rock across the middle of the lake from west to east. It is considered extremely probable that the sand bottom so prominent on the western shore is shelving over rock. The whole appearance of Campbell Park headland, and the manner in which it points directly across the sand-rock bottom in the centre of the lake, indicate a probable similarity of the adjoining areas marked Soil E. It is highly significant that soft limestone rock was found in borings on the shore line, on the south-west part of the lake, in four places between Rumplyander and the Black Flag Beacon, as well as to the west of Meningie township, and at intervals up the eastern shore. In several other cases, calcareous sand was found but no rock to a depth of 6 feet, and all along the north-eastern shore no sign of lime was found in borings, although the hills descending to the lake show outcropping stone.

In constructing the cross-section diagrams (Fig. 2) some smoothing of the lines has been done to show the succession of colour changes in the deep clay, which may be seen generally in the fresh mud. The scale employed emphasizes the sharp dipping away of the sand bottom, such that the change from a comparatively shallow sand, say, under 4 feet of clay, to a clay more than 13 feet deep, may occur in a distance of 3 chains. The actual steepness of this slope is not shown exactly, owing to the distance apart of the borings, but there are two cases illustrating this feature in Fig. 2 (A). There is no information to show the full depth of the clay of Soil A, and there is no reason to postulate a sand bottom shelving from the surrounding areas of the other soil classes. On the river swamps, the clay is indefinitely deep, in one case near Wellington being over 40 feet, and the areas of Soil A are assumed to be similar, silted-up river channels, dating from the time when the Murray flowed through Lake Albert to join the Coorong. The reason why the areas of Soil A representing an ancient channel do not appear as continuous lies in the necessary roughness of the survey, in which borings were spaced from a quarter to a half mile apart, and probably narrow connecting strips of this soil exist, though not mapped. The sand bottom dividing the central from the southern area of type A soil represents, in part at least, extensive sand bars and spits, while Meningie Bay is a good example of a billabong cut off by sand bars from the diverted river course. Subsequent to the change in course of the river, whereby it flowed down Lake Alexandrina, more or less isolating

Lake Albert, a silting up of the channels, and later the lake generally, began and proceeded with extraordinary uniformity. The sedimentation, apart from the surface 2 feet of mud, must have been under ideal conditions for a long period. Deposition in more recent times has been influenced by the introduction of a greater proportion of silt and fine sand, probably wind-borne from the surrounding country subsequent to settlement.

(*b*) *Examination of the Shore Line Soils.*—A shore line traverse of Lake Albert emphasized two points—that few of the soils at the water's edge bear any noteworthy resemblance to the lake bottom, except for Soils E and F, and that no conclusions can be drawn as to the nature and quality of the lake bed from such observations. From the laboratory examination of mud samples from the shore (p. 90), no reliable opinion can be formed of the deep clays of the lake.

In all, 27 borings were made and nine samples collected in the course of the examination of the shore. The parts of particular interest are the lagoon at the south end and the north-eastern bay adjoining Waltowa Swamp, since all the remainder appears to be deep sand or rock. Probably the lagoon is mostly deep mud (Soil A) with a few sand banks. At the water's edge a sand bottom was struck under 66 inches of clay. An analysis of the dark-green clay, 30-54 inches (sample 1656), places it as a heavy clay, less heavy than the lake mud, and with slightly more fine and coarse sand, but essentially the same. As a whole, the lagoon is thought to be similar to the main lake soils A, B, and C, mainly A. The north-eastern corner of the lake is in a different class, approximating to Soil G. A comparison of samples 1661-3 and 1637-9, both of which are underlain by limestone rock at about 54 inches, shows certain differences, such as in the physical composition, the presence in the former of more organic matter and of reed remains not observed in the lake mud.

4. Laboratory Investigations.

(*a*) *Mechanical Analysis.*—Several profiles from the lake bed and six of the shore-line samples were analyzed, the results being set out in Tables 3 and 4 respectively. The outstanding features are the high percentage of clay and the considerable degree of uniformity in composition of the deep clays, both throughout the profile and from different parts of the lake. The samples of Types A, B, and C contain very little sand, except in the surface layers, which have received wind-borne sand from the surrounding country. The clay content is about 50 per cent. in the surface layers, increasing to 70-75 per cent. at and below about 24 inches. Expressed as fractions of the mineral content only, these features are even more striking, as, for instance, in Hole 1, where the four samples between 15 and 141 inches have analyses identical within the limits of experimental error, while the corresponding samples from Holes 4, 11, and 16 are substantially the same, the clay content being about 80-90 per cent. The Type D soils analyzed are also very heavy, but there is considerably more sand present, mainly fine sand, while the Type G profile examined is very similar to the Type A, B, and C samples.

These analyses are shown diagrammatically in the summation curves in Fig. 3, which also includes for comparison curves for some shore-line samples.

Shrinkage on Drying.—The large amount of clay present will, to a considerable degree, govern the extent of the shrinkage on drying. Three samples were sealed immediately after removal from the lake bed, and the volume shrinkage on air drying was determined in the laboratory. The method employed was to take a measured volume of the wet soil (a Keen-Raczkowsky box was used) and allow it to dry in air to constant weight. The volume of the residue was determined as accurately as possible by means of the Haines mercury displacement bottle. The loss of volume as a percentage of the wet volume is given below:—

Hole.	Depth in Inches.	Loss of Volume. %
16	0-12	87
15	18-30	89
16	72-84	87

This represents the shrinkage when the soil becomes fully air-dried, a condition which would not be reached in the field, so that in practice the reduction in volume would be somewhat less, though still very large. It must be borne in mind also that this shrinkage would occur in effect in one dimension only, i.e., vertically.

TABLE 4.—MECHANICAL ANALYSIS OF SAMPLES FROM SHORE LINE.

Location	Southern Lagoon		Eastern shore	North-eastern corner, near Waltowa Swamp		
Sample No.	1656	1658	1660	1662	1663	1661
Depth in inches	30–54	66–78	48–54	20–27	27–33	48–54
Coarse sand	6.6	52.7	23.6	0.1	0.3	20.9
Fine sand	15.9	44.2	36.0	20.0	10.0	20.0
Silt	6.2	0.4	3.3	40.4	35.8	7.9
Clay	50.1	0.6	29.7	25.6	36.4	33.2
Loss on acid treatment	3.9	0.5	3.2	3.2	4.1	13.3
Moisture	10.6	0.4	4.9	7.2	8.7	5.8
Loss on ignition	13.6	1.1	3.2	7.9	9.7	7.5
$CaCO_3$	..	..	2.1	..	..	11.8
pH	5·1	5·3	8·4	7·9	7·7	8·4

(*b*) *Organic Matter and Nitrogen.*—The organic matter present differs in appearance from that present in the soils of the Murray River swamps, there being no suggestion of the black humus of the latter. The brown and green colours of the deep clay layers seem to be due to organic matter, a conclusion which is supported by the odour of the samples when fresh.

Nitrogen estimations lead to the conclusion that the organic matter content increases with depth, the upper layers being fairly uniform and averaging about 0.25 per cent. The highest figure obtained was 0.51 per cent., this being for one of the brown clays at 9-12 feet. Organic carbon for a series of soils was determined by direct combustion, the figures being parallel with those for nitrogen. Both carbon and nitrogen analyses are tabulated in Table 5.

TABLE 3.—MECHANICAL ANALYSIS OF LAKE ALBERT MUDS.

Hole No.	1						2					4				
Soil Group	A						D					C				
Sample No.	1585	1586	1587	1588	1589	1590	1591	1592	1593	1594	1595	1600	1601	1602	1603	1604
Depth in inches	0-6	6-15	15-33	33-69	69-105	105-141	0 6	6 12	12-36	36-54	54 57	0 12	12 36	36 72	72-102	102-114
Coarse sand	8·0	0·7	0·4	0·4	0·4	0·4	0·4	0·3	2·0	6·0	Coarse Sand	9·8	0·4	0·4	0·6	Coarse Sand
Fine sand	12·0	1·8	1·0	1·0	0·9	1·2	3·9	5·0	10·1	14·8		8·7	1·1	0·6	1·6	
Silt	17·1	8·3	6·7	6·6	6·8	6·3	19·7	22·6	17·6	5·1		18 6	9·7	7·1	6·5	
Clay	48·5	70·8	74·7	74·0	74·0	70·4	60·7	57·2	55·3	59·0		48·2	71·8	72·5	71·2	
Loss on acid treatment	3·3	3·7	3·7	3·7	3·8	3·9	5·8	3·5	3·6	3·4		3·7	4·4	3·8	3·7	
Moisture	7·0	10·8	11·0	10·8	9·1	9·6	7·8	7·2	8·1	8·1		7·8	10·5	11·7	11·5	
Loss on ignition	10·5	12·3	12·5	13·2	15·7	16·4	11·6	11·4	10·7	11·0	..	10·4	12·9	14·4	15·5	..
pH	7·4	7·0	6·6	6·8	7·7	7·5	7·4	7·5	5·7	6·7	6·2	6·0	5·8	5·8	6·6	6·9

Hole No.	11					13			16				
Soil Group	A					F			A				
Sample No.	1630	1631	1632	1633	1634	1637	1638	1639	1647	1648	1649	1650	1651
Depth in inches	0–6	6–24	24–78	78–102	102–132	0–12	12–24	24–54	0–12	12–30	30–84	84–114	120–156
Coarse sand	2·0	3·0	0·5	0·4	0·7	2·2	0·4	1·6	0·4	4·0	0·4	0·3	0·4
Fine sand	12·2	15·1	2·8	2·0	2·1	8·3	2·0	4·4	9·2	18·2	4·3	3·8	2·1
Silt	25·7	28·0	15·7	10·8	10·0	25·7	10·9	9·1	25·0	19·5	12·4	11·8	6·6
Clay	46·9	41·1	66·8	71·1	70·6	50·0	72·6	70·7	49·7	47·6	67·1	69·7	74·5
Loss on acid treatment	2·5	1·9	2·5	2·5	2·2	2·5	2·9	3·1	3·1	1·9	2·5	2·5	2·6
Moisture	5·8	5·1	7·4	7·7	7·9	6·8	8·6	8·4	6·5	5·6	9·4	7·7	8·5
Loss on ignition	10·0	8·9	11·5	13·3	15·7	10·6	12·4	11·9	10·1	8·8	10·8	11·9	12·1
pH	7·9	7·6	7·8	7·9	7·8	7·6	7·8	7·8	7·7	7·2	7·3	7·6	7·8

TABLE 5.—NITROGEN AND ORGANIC CARBON IN LAKE ALBERT MUDS.

Hole No.	Sample No.	Depth in inches.	pH.	Nitrogen.	Organic Carbon.
				%	%
2	1593	12–36	5·7	0·29	2·7
4	1601	12–36	5·8	0·27	..
4	1603	72–102	6·6	0·37	4·8
5	1605	0–12	4·8	0·20	..
5	1606	12–30	6·0	0·29	..
6	1610	0–6	5·6	0·27	2·9
6	1611	12–24	6·7	0·25	2·9
6	1612	36–66	7·1	0·32	4·1
6	1613	72–112	7·1	0·39	5·0
6	1614	112–150	7·2	0·51	6·4
11	1631	6–24	7·6	0·22	2·2
13	1637 + 1638	0–24	7·8	0·28	3·0
13	1639	24–54	7·8	0·24	2·7
14	1640	0–6	7·5	0·17	..
14	1641	6–30	7·6	0·20	..
15	1643	12–36	7·4	0·23	2·3

(*c*) *Hydrochloric Acid Extract.*—Standard hydrochloric acid extractions were carried out on three samples, the results being given in Table 6, together with those obtained in 1904, referred to in an earlier section. Potassium is present in satisfactory amount, comparable with that present in the soils of the Murray River swamps, but the phosphoric acid content is very variable, being generally considerably lower than in the swamp soils. Calcium is also somewhat low, considering the amount of clay present.

TABLE 6.—POTASSIUM, CALCIUM, AND PHOSPHORIC ACID IN LAKE ALBERT MUDS.

Location.	Sample No.	Depth in inches.	P_2O_5.	K_2O.	CaO.
			%	%	%
Hole 10	1626	0–21	0·089	1·12	0·38
Hole 11	1631	6–24	0·050	0·89	0·27
Hole 13	1637 + 1638	0–24	0·088	1·22	0·40
Shore, near Koorompang ..	*A	0–12	0·024	0·25	0·36†
South of Hole 13	*B	0–12	0·075	0·97	0·22†
East of Hole 12	*C	0–12	0·079	0·92	0·17†
Between Holes 11 and 12 ..	*D	0–12	0·161	1·05	0·21†
Between Holes 1 and 2 ..	*E	0–12	0·140	1·35	0·42†
South-western shore ..	*F	0–12	0·115	1·35	0·44†
Near Hole 16	*G	0–12	0·066	0·78	0·16†

* From Report on Soils of Bed of Lake Albert, 1904. (Department of Agriculture, South Australia.)
† Soluble in weak acid.

(*d*) *Soluble Salts.*—Owing to the scanty accommodation for air drying the soils on the survey launch, it was found necessary to speed up the process by absorption of much of the water on paper pads. In consequence, the salt content of the laboratory samples is considerably lower than it would be in the reclaimed lake bed, except in the case of some of the samples dried without the removal of water in this way. Chloride ion only was determined, the values obtained ranging from 0.4 to 1.3 per cent. While accurate conclusions are not possible in view of the above it is possible to state that the salt content is high

throughout the profile, and would be of the order of 2 per cent. of the dry soil if the lake waters were removed by drainage. Evaporation of the lake in its present condition would lead to a much greater percentage in the surface layers*.

(*e*) *Reaction.*—The soils have a reaction fairly close to neutrality, 57 of the 66 samples examined having pH values between 6.0 and 7.9; of the remainder, five have pH values between 5.6 and 6.0, and the only two of higher pH (8.4) contain calcium carbonate. The reaction changes but little with depth, except in a few instances, the most striking of which is in Hole 12, where the surface 6 inches is pH 3.9, while the 6-15 inch layer is pH 8.4. It is probable that the more acid values are the result of changes after the samples were taken, as the water of the lake itself had a reaction of pH 8.0-9.0†.

The reaction values quoted were obtained with the quinhydrone electrode, except in the case of the lake water, for which an indicator determination was made.

(*f*) *Replaceable Bases.*—The replaceable bases were determined in nine samples, representing three locations. The analyses are recorded in Table 7. The total bases amount to from 31 to 53 milliequivalents per 100 gm. soil. Magnesium is present in unusually large amount, about 50 per cent. of the total bases, whereas calcium accounts for about 22 per cent. Potassium is fairly constant, constituting 8 per cent. of the total. Sodium is not unduly high, though much higher than in the soils of the swamps. The three surface soils contain considerably more replaceable sodium than the soils below them, reflecting the present salinity of the lake water. Apart from this surface difference, there is no appreciable variation in the proportions of the cations throughout the one deep profile studied. This constancy of composition down to 13 feet is in accord with the uniformity exhibited in the mechanical analyses. In general, the soils differ from the swamp soils in the greater amount of sodium and smaller amount of calcium, which, in view of their common origin, is probably due to the action of sodium chloride from the sea.

TABLE 7.—REPLACEABLE BASES IN LAKE ALBERT MUDS.

Hole No.	Sample No.	Depth in inches.	pH.	Clay.	Milliequivalents per 100 grm.					Percentage of Total Bases.			
					Ca.	Mg.	K.	Na.	Total	Ca.	Mg.	K.	Na.
10	1626	0–21	7·5	53	9·3	18·4	3·1	9·5	40·3	23·1	45·6	7·7	23·6
10	1628	21–33	6·5	49	9·7	16·9	2·4	5·7	34·7	28·0	48·7	6·9	16·4
13	1637	0–12	7·6	50	8·2	18·6	2·3	8·0	37·1	22·1	50·1	6·2	21·6
13	1638+1639	12–54	7·8	72	16·3	25·4	2·9	8·0	52·6	31·0	48·3	5·5	15·2
16	1647	0–12	7·7	50	7·8	18·1	3·0	8·1	37·0	21·1	48·9	8·1	22·0
16	1648	12–30	7·2	48	6·5	17·6	2·5	4·9	31·5	20·6	55·9	7·9	15·6
16	1649	30–84	7·3	67	8·3	23·1	3·6	7·7	42·7	19·4	54·2	8·4	18·0
16	1650	84–114	7·6	70	8·2	25·4	4·1	8·0	45·7	17·9	55·6	9·0	17·5
16	1651	120–156	7·8	75	8·7	26·1	4·3	10·5	49·6	17·5	52·6	8·7	21·2

* A sample of water from the lake contained 1·00 per cent. of salt.

† Robertson (*Proc. Roy. Soc. Sth. Aust.*, 53: 39, 1929) found that the reaction of the water of Lake Alexandrina varied from pH 8·0 at Murray Mouth to pH 8·9 off the Albert Passage. The present authors carried out observations from the Albert Passage to Murray Bridge, and found the water of Lake Alexandrina to have a reaction varying from 8·7 pH to 8·0, pH and the fresh water of the river of pH 7·5.

5. Lake Albert as a Reclamation Project.

The arguments put forward in the past, as set out in the first section of this paper, have been largely negatived by the details of the soil description and analyses of the samples discussed above. The data may be summarized under five headings—

(*a*) Variability of the soils.
(*b*) Uneven surface following reclamation.
(*c*) Quality of the soil.
(*d*) Salt content and its removal by leaching.
(*e*) Texture and working of the soil.

(*a*) The question of the suitability of the lake bed for reclamation depends principally on the uniformity of the soils. The Murray River swamps have certain uniform features, such as similarity of profile, both physically and chemically, and free permeability to water, allowing the ready removal of salt. The grouping of the lake bottom muds into four varieties by combining Soil A with B (deep clay), C with D (moderate depth of clay over sand), E with F (surface sand or rock), and G (shallow clay over rock) simplifies the problem. There is little doubt that Soils E, F, G, and some of D, or roughly 50 per cent. of the total surveyed area, would prove of little value in an irrigation project. Narrowing the range to the definitely unsuitable Soils E and F, about 13,350 acres, or 39 per cent. of the total surveyed area, is eliminated. In either case, this proportion seems too high to justify the scheme. The fact of the presence of a considerable area of moderately deep or deep clays is not a valid reason for reclamation, in the first place, because it will constitute the lower portion of the dry area, and, therefore would be liable to salt injury, and, in the second place, because, although richer than the average local soil, its relation to water percolation is not known, nor can its quality and permeability be judged by analogy to the river swamp areas. Reclamation would be considered more favorably only if the proportion of deep clay to the whole were much greater than appears to be the case.

(*b*) As discussed in a previous section (p. 90), the shrinkage of mud is very great on drying, even of mud from 4 to 6 feet from the surface. The surface 6 inches is very generally a slime, which on drying contracts to a thin layer, little more than a film. It is highly probable that the shrinkage of the upper 2 feet of soil on drying *in situ* would be 50 to 75 per cent., and if the height of the water table allowed a greater depth to dry out, the gross shrinkage would be not less than 50 per cent. This entails the formation of an uneven surface, and for irrigation systematic grading would be necessary. The greatest shrinkage would probably occur in areas of moderate to deep clay, and the tendency would be to reduce the clay cover on the shallower soils, and hence lower their initial value. The lake bed is fairly even, judged by the depth of water at the time of the survey. Excluding all parts within ½ mile of the shore line, the recorded range of water depths is 27 to 66 inches. The whole question of the topographic appearance of the lake bed on drying out, and the measures necessary to prepare it for an irrigation project, would require careful consideration.

(*c*) The quality of the soil has been discussed in a previous section. The main characteristics affecting reclamation are—

(i) The extreme heaviness of the soil.
(ii) The high content of soluble salts.

(iii) The (relatively) moderate amounts of organic matter and nitrogen present compared with the swamp soils of the Lower Murray River.

(iv) The reaction, which tends to be neutral or slightly alkaline in the deep clay soils.

(v) The high figure for total replaceable bases and the presence of approximately 20 per cent. of the total as sodium.

(vi) The content of plant nutrients, of which potash is high, phosphoric acid is moderately high, and lime is low.

(*d*) With the small samples available it was not possible to determine the movement of water through the soil experimentally. The assumption that these soils behave in similar fashion to the river swamp soils is not warranted on the evidence available. There is a large amount of soluble salts present, and it is thought that their removal by leaching would be difficult, in view of the high clay content and the trouble experienced in filtration during mechanical analysis. The existing salt concentration is too high for crop plants, and probably satisfactory development would be possible only by the removal of 75 per cent. of the soluble salts present. The cost and practicability of installing an efficient drainage scheme to cope with this problem would need close investigation.

(*e*) The agricultural development would depend principally on the solution of the salt and drainage problem. Assuming this to be capable of solution, it is very probable that a good pasture could be maintained on the deeper soils and yield satisfactory returns to dairying and intensive sheep grazing. Cultivation for annual crops would appear to be difficult on account of the heavy texture of the soil, as a friable state is not anticipated. The problems of irrigation would include the maintenance of a water table at a sufficiently low level, and would be materially complicated by the variability of the lake bed, the rocky foundation in one section allowing of little or no percolation, while the deeper sands would be difficult to irrigate side by side with the clays, leading inevitably to the seepage problems associated with these conditions.

Apart from the irrigation aspects, these shallower types have little value for dry farming unless the remaining deep clays have a proportionately high value, which on the evidence available is not thought to be probable.

The Export of Citrus Fruit: Recommendations by Citrus Preservation Committee.

References to the Citrus Preservation Committee have been made in previous issues of this *Journal* (see Vol. 1, pp. 307, 372; Vol. 2, p. 56; Vol. 3, p. 69). Briefly, its main object is to investigate problems connected with the storage and transport of citrus fruit with a view to developing methods whereby that fruit may be landed on outside markets in a satisfactory condition. For some time past, the plantings of citrus in Australia have been increasing, and during the next few years the production will in all probability be considerably in excess of Australia's own requirements. Already, the local consumption per head is relatively very high, and the problem of increasing it appreciably correspondingly difficult. The development of an export trade in the near future would thus seem to be a necessity, if the industry is to continue with any degree of prosperity. Work such as that now in hand by the Committee is vital to such a development. In the light of the results it has obtained to date, the Committee has recently issued recommendations dealing with methods of handling citrus intended for export. A copy of these is printed below.

It would be but appropriate to state that the Committee's activities are made possible by the ready co-operation of the various bodies which have representation on it, as follows:—W. J. Young, D.Sc., Associate-Professor in Biochemistry, University of Melbourne (Chairman); W. D. Bracher, Victorian Railways; Captain D. Halhed and G. E. Kitchin-Kerr, Victorian Central Citrus Association; J. Hepburn, Government Cool Stores, and F. M. Read, M.Agr.Sc., Victorian Department of Agriculture; W. Ranger, Committee of Direction of Fruit Marketing, Queensland; and E. Archer, M.Sc. (Secretary).

A. *Regulations affecting Export.*—All fruit must comply with the Regulations under the Acts dealing with the overseas export of fruit, and, in particular, those relating to the control of the quality and the grading of the fruit, the type of case, and the markings on the case.

B. *Type of Fruit.*—In view of the fact that the Regulations set out in detail the type of fruit permitted for export, there is not much that can be added under this heading. It is only necessary to emphasize that only first quality fruit should be sent. The harmful effect on the trade would be very great if sour or immature oranges were included.

C. *Methods of Handling in Grove.*—During all operations it is most important to avoid injury to the rind. All experiments have definitely pointed to the necessity for great care in the handling of the fruit. Considerable loss is produced by mould infection following damage to the rind, and this damage can be prevented by careful handling in the following manner:—

(i) Gloves should be worn during all operations of harvesting, grading, and packing.

(ii) Under no circumstances should the fruit be pulled from the tree.

(iii) Blunt-nosed clippers should be used, and in the actual cutting of the fruit the greatest care must be taken that no protruding stalk be left. It may be necessary to make a second cut in order to remove any superfluous wood.

(iv) No fruit resting on the ground or hanging within a foot from the ground should be used for export.

(v) The fruit should not be harvested in damp weather.

(vi) Picking bags are not recommended as the ideal receptacle, because in a bag the oranges are liable to be rubbed together and the rind bruised by the movements of the packers. It is strongly recommended that growers make an effort to provide the pickers with a box of the capacity of half a bushel; the box should be well padded inside, and have straps for hanging across the shoulder.

(vii) Care should be taken to see that the fruit is not dropped, but transferred from one receptacle to another with the same care as would be given to eggs. If any orange is accidentally dropped or mishandled in any way during the operation, it should be immediately rejected, as otherwise it may be the means of ruining a whole case of fruit.

(viii) The most suitable type of field box is the box used in the canning industry, namely, a kerosene case cut open on one side with cleats nailed to each end for ease of handling.

(ix) Care should be taken to see that the field boxes have no inner surface projections of any kind; there should be no nails, protrusions of wood or sharp knot holes, all of which are liable to cause injury to the rind.

(x) If the weather is dry and warm, sweating in a well-ventilated shed is recommended for a period of up to seven days. Under moist conditions, however, sweating will be quite ineffective, and therefore is not advised, unless some chamber in which atmospheric conditions can be controlled is available.

(xi) In transporting the fruit from the grove to the shed, care should be taken to pack the boxes squarely on top of each other, and the truck should be driven carefully so as to minimize the shaking as much as possible.

D. *Packing House Methods.*—The importance of scrupulous cleanliness in the packing sheds and of all parts of the machinery used cannot be over-emphasized. To ensure this, the following precautions should be taken:—

(i) Old fruit should not be left lying about. All mouldy or damaged fruit should be removed from the shed and destroyed.

(ii) The grading machine should be sprayed daily with a formalin solution of 1 part of 40% commercial formalin to 20 parts of water.

(iii) Where practicable, the whole of the shed should be sprayed at intervals with this solution. The floor in the vicinity of the packing operations should always be regularly sprayed.

(iv) Gloves should be worn during all sorting, grading, and packing.

(v) It is important that the grading machine should be free from all rough, sharp edges or projections, or surfaces which might injure the fruit.

(vi) It is essential that the fruit should be carefully culled, and that any which shows marked signs of blemish should be rejected. Off-type fruit should be rigorously excluded.

(vii) Dirty fruit should under no circumstances be exported. Cleaning may necessitate washing and polishing, and, unless the proper facilities exist for efficient washing and quick drying of the fruit, washing should not be attempted, and all dirty fruit should be discarded. Where proper facilities for washing exist, the sodium bicarbonate treatment is recommended, as it is beneficial for reducing the decay due to moulds. This consists in immersing the fruit in 5% sodium bicarbonate for eight minutes at temperatures of 112–120° F. and drying on towel dryers. A full description of the methods was published in the *Journal of the Council for Scientific and Industrial Research*, Vol. 3, No. 2, May, 1930, copies of which may be obtained from the Secretary, Council for Scientific and Industrial Research, 314 Albert-street, East Melbourne. For efficient drying after this treatment, loose towels should be placed on the fruit as it passes over the revolving towel dryer. The revolving towel soon becomes so wet that it does not dry the fruit, but merely removes the excess of moisture. If dry towels be tacked on the machine so that they rest loosely on the fruit, the efficiency of the apparatus is increased enormously and the fruit can be actually dried. These loose towels, which should be made to fit the machine, need to be changed and dried as soon as the condition of the fruit points to the necessity.

(viii) Only export citrus cases (24 x 11½ x 11½, inside measurements) should be used. The space between the side boards must not be more than ½ inch. Each case should be dressed, particularly on the inside, and be free from projecting nails, loose splinters, or anything that might injure the fruit.

(ix) In packing, great care should be taken to see that the fruit is to the correct height in the case, in order that "lidding" can be carried out without damage to the fruit. The use of box guards on the middle division piece and round the inside is recommended during "lidding" in order to prevent injury.

(x) The experiments of the Committee have not as yet gone far enough to recommend a definite method of wrapping. It is considered, however, that wrapping in an attractive paper is advisable in that it enhances the selling qualities very considerably.

E. *Transport by Rail.*—The cases should be carefully packed in a railway truck in such a way that undue movement is prevented. They should be stacked on end, and for preference should be battened, but if battening is impracticable the cases should be stacked in such a way as to prevent as much movement as possible. Cleanliness in the trucks is as essential as in the packing sheds.

F. *Precooling.*—Broadly speaking, all fruit consists of living matter and materials which have been stored up in the fruit during the period of growth on the tree.

After the removal of the fruit from the tree, the living matter is dependent for its maintenance upon the materials stored up, and when these are used up the fruit dies. The life of the orange, therefore, is limited, depending upon the quality of stored material and on the rate at which this material is used up.

The vital activity of the fruit depends upon its temperature, increasing with rise of temperature at an accelerated rate, and the object of storage at a low temperature is to reduce its rate of living and so prolong the life of the fruit.

This using up of stored material is accompanied by actual production of a proportional quantity of heat, and so, if the fruit be loaded hot into the ship's hold, the refrigeration machinery has to remove not only the heat already in the fruit, but also heat which is constantly being produced. It may, therefore, be some time after loading before the temperature at which it is desired to carry the fruit is attained throughout the stack. This means that the life of much of this fruit is shortened.

All fruit should, therefore, be precooled to 40 deg. F. before being loaded into the ship, since precooling lowers the rate of living, and thereby lengthens its life.

As oranges have only a limited life, it follows that all time taken up after picking, sweating, packing, &c., is so much time taken off the storage life of the fruit, which really starts when the fruit is removed from the tree.

It is, therefore, essential that the fruit should reach the precooler as soon as possible after picking, so that the vital activity, and therefore the reduction of its stored material, is reduced to a minimum.

G. *Ship Transport Conditions.*—The temperature of storage on the ship should be 38 deg., and the holds should be subject to periodical ventilation.

General Instructions.—It has already been stated that the life of the fruit from the time it leaves the tree is strictly limited, and any unnecessary delay between the time of harvesting and the time of sale means a shorter time during which it will be in good marketable condition.

It is, of course, manifestly impossible to make arrangements for a shipment of any size without at least some of the fruit having been harvested earlier than the rest. As, however, the process of decay is very much slower when once the fruit is in cool storage, it is essential that the actual processes of harvesting, washing, packing, and transport to the cool stores must be managed as expeditiously as possible. If the fruit must be held for some time before shipment, it should be held in cool store, and not in the packing shed.

An Outline of the Possibilities for the Export of Quick-frozen Packaged Meat (and Fruits).

By J. R. Vickery, M.Sc., Ph.D.

Dr. Vickery is a graduate of the University of Melbourne, who left Australia in 1926 as an Exhibition of 1851 Scholar. After spending four years at the Low Temperature Research Station established at Cambridge by the British Food Investigation Board, he was appointed to the staff of the Council. He recently returned to Australia via America. The brief article that follows has been prepared by him partly in the light of the information that was then made available to him and partly in the light of the knowledge he had previously gained at Cambridge.—Ed.

1. Introduction.

A short account of the objects of the quick-freezing of various foodstuffs, and the applications of the method in the United States of America, has recently appeared in the *Journal.** In the present article, a brief description will be given relating to the methods which have been applied to the quick-freezing of packaged meats, together with a brief summary of the possibilities and difficulties of applying these methods in Australia.

There appeared to be a demand in the United States of America for attractively-packaged meat, and the meat packers believed that quick-freezing would enable these cuts to be placed in the hands of the consumer in a fresher, and, perhaps, more palatable, condition than that of similar chilled "cuts." Stimulated by the commercial success of quick-frozen fillets of fish, several meat-packing firms made extensive investigations into the special technique required for the freezing, storage, transport, and marketing of the packaged meat, and, at the the present time, four meat-packing establishments are producing these quick-frozen cuts on a fairly considerable scale.

2. Technique.

(*a*) *Preparation of the "Cuts."*—At the present time, in the United States of America, all the usual "cuts" from carcasses of lamb are being quick-frozen, but only certain choice "cuts" from quarters of beef and sides of pork are being used. For instance, porterhouse, rump and sirloin steaks, rib-roasts of beef, cuttings minced into Hamburger steaks, pork loins and pork chops, form the principal packaged meats from beef and pork. A limited number of sheep's and hogs' kidneys, calves' livers, and lambs' sweetbreads, are also being packaged and quick-frozen.

When the meat is to be frozen in cartons, the excess fat and bone is removed, and the meat pressed into a shape that will fit neatly into the standard-sized cartons, which have been impregnated with paraffin wax, and lined with loose non-porous cellophane. This cellophane is then folded over the meat as neatly as possible, and the cartons pass to a wrapping machine, which places and seals a transparent, waxed-paper wrap on the cartons.

(*b*) *Freezing.*—The principal feature of most methods of quick-freezing is the use of freezing media having relatively high specific

* Vol. 3 (1930), p. 185.

conductivities of heat—usually concentrated solutions of sodium or calcium chlorides. The simplest and most obvious method of freezing by these methods is, of course, by means of direct immersion in the cold brine. In practice, however, this method has two serious disadvantages, viz., the penetration of salt into the tissue, and the formation of a discoloured superficial layer due to the oxidation of the red muscle pigment, haemoglobin, to the brown pigment, met-haemoglobin. Many methods have been elaborated, therefore, to secure effective indirect contact with the brine, and, for this purpose, the meat may be placed on metal plates or belts with which the "brine" is in continuous contact, or the non-porous character of the cartons may be relied upon to prevent the contact of the meat and brine.

The two methods based on these principles which have been employed for the rapid freezing of meat are the Birdseye and Zarotschenzeff processes. In the former process, the cartons of meat are inserted between two slowly-moving belts of Monel metal, on which calcium chloride brine, at a temperature of — 45° F. (approximate), is sprayed. Indirect contact is therefore secured on both faces of the packages, and to eliminate air pockets inside the packages, which naturally would increase the time of freezing, a uniform pressure is exerted on the belts by means of adjustable rollers. It is claimed that the average time taken to reduce the temperature of a package of meat 2 inches in thickness to 0° F. is usually 80 to 90 minutes. In the Zarotschenzeff process, the cartons, wrapped similarly to those in the Birdseye method, are placed on galvanized iron racks in a chamber fitted with numerous nozzles, through which is forced a fine rain of concentrated solution of sodium chloride at a temperature of — 5° F. In order to reduce the leakage of heat into the chamber, the walls and ceiling are also fitted with grids of "direct expansion" pipes. Although the temperature of the brine used in the Zarotschenzeff process is considerably higher than that in the Birdseye process, owing to the effective removal of heat by convection, the time of freezing of a piece of meat 2 inches in thickness is not appreciably greater than in the Birdseye process.

For freezing works where a supply of brine at a temperature of — 45° F. may be difficult to obtain, Birdseye has recently introduced a rather novel apparatus which is said to freeze packaged meats as rapidly as his original machine. It consists essentially of direct ammonia-expansion pipes embedded in rigid plates constructed of an aluminium alloy 2 inches thick, and the plates are arranged in a "concertina" fashion to open and close relatively to one another by means of an automatic hydraulic ram. This arrangement allows the plates to be adjusted accurately to various distances up to 4 inches apart. The grids of pipes are inter-connected by means of hard, flexible, rubber hose pipes, which have been specially designed to withstand very high pressures. The packaged meat to be frozen is placed between the plates, and the spaces between the latter are reduced until an effective contact is made on the two faces of the package; an automatic pressure regulator prevents the plates from pressing too tightly on the packages.

Two meat-packing establishments in America have avoided the hazards of the brine-freezing methods by freezing the "cuts" in air at very low temperatures of the order of — 50° F., but, unfortunately, details of this method are not yet available.

Several other methods of quick-freezing are in general use for the freezing of fish, but, as yet, they have not been applied on a large scale to the freezing of cuts of meat.

(*c*) *Storage.*—After the completion of freezing, the cartons are usually packed in large strawboard cases fitted with corrugated strawboard linings, which are effective insulators.

There is a considerable diversity of opinion at the present time as to the correct temperature for the storage of the packaged, frozen meats, but inquiries at the research laboratories of the meat-packing firm which has carried out the most careful investigations in this field, showed that, when the duration of the storage exceeded three months, the temperature should be as low as possible, and, in any case, should not exceed 0° to + 5° F. Investigations have shown that, during storage, the larger ice crystals in the meat tend to grow at the expense of the smaller crystals, but that the tendency for this distillation of aqueous vapour to take place is less the lower the temperature of storage. If the storage be unduly prolonged, or if the temperature be too high, the growth of the larger crystals becomes so great that it is difficult to distinguish the texture of the quickly-frozen meat from that frozen slowly in air. All investigators are agreed that considerable fluctuations in the temperature of storage in themselves accelerate the formation of the larger ice crystals. It is apparent, therefore, that constant temperatures, lower than are normally employed for the storage of frozen foodstuffs, are required for the successful storage of the quickly-frozen, packaged meat.

(*d*) *Transport.*—As far as could be ascertained, the packaged meats are transported by rail in the United States of America in the normal insulated cars refrigerated by a mixture of ice and salt in end bunkers. In these vans, it is difficult, however, to obtain temperatures lower than 25° F., and, on this account, extensive tests are being made with mechanically-refrigerated railroad cars, which, naturally, are costly to build and operate.

For long-distance transport by sea, it is obvious that the conditions necessary for the land storage of quick-frozen meats will apply also to the holds of ships.

(*e*) *Marketing.*—In the United States of America, glass-fronted, refrigerated show cases, capable of maintaining a uniform temperature of 10° to 20° F., are considered necessary for the marketing of the quickly-frozen, packaged meat in the retail shops. Considerable ingenuity has been shown in the manufacture of cases on which frost will not deposit even in the warmest weather, but such cases are expensive, costing upwards of 500 dollars for a small unit, exclusive of the refrigerating plant. It is natural, therefore, that the large chain-stores have so far been the principal channels of the retail distribution.

3. Possibilities of the Method.

With the recent large increase in the numbers of families living in flats, and a decreased supply of domestic workers, a considerable demand has been created for foodstuffs which may be prepared with the minimum amount of time and effort. In these circumstances, the attractively-wrapped cuts of meat from which, in most cases, the bones have been removed, are a useful innovation. While certain meat-packing firms have stressed the hygienic aspect of quick-freezing, the

consensus of disinterested opinion in the United States of America inclines to the belief that the partial success obtained with quick-frozen meats is due almost entirely to its being retailed in an attractively-packaged form. In spite of the fact that there are, as yet, only four meat-packing firms which are actively engaged in this trade in the United States of America, and this only on an experimental scale, it seems probable that there will always be a limited demand in America for packaged meat, either chilled or quick-frozen.

The different social conditions prevailing in Great Britain and Europe make it difficult to predict whether a similar demand will exist there, and, in these circumstances, exploration of the possibilities by means of several small shipments of quick-frozen packaged meats from Australia would seem to be desirable before the export-trade interests become deeply committed to the process. If a considerable market were found to exist, the early experience thus obtained by the Australian exporters would stand them in good stead if other meat-exporting countries entered the field. Inquiries made in America showed that the cost of packing, freezing, and handling each pound of meat until the completion of freezing, varied from 2 to 2½ cents, the cost of freezing being of the order of a ½ cent per lb. The cost of freezing being a small fraction of the total costs, judgment of the efficacy of the various processes for quick-freezing resolves itself chiefly into a study of their capacities to produce frozen "cuts" which, on thawing, closely resemble the comparable fresh, unfrozen meat—i.e., it involves a comparative study of the rates of freezing which are normal to the methods. If, therefore, the production of quick-frozen, packaged meat be contemplated in Australia, the process which freezes the most rapidly should receive the first consideration.

As a means for the profitable disposal of the undamaged portions of badly bruised carcasses which are usually prohibited from being exported, the method of quick-freezing has distinct possibilities.

Since edible offal, such as kidneys, livers, &c., usually undergo considerable alteration in texture during the course of the comparatively slow freezing at present practised, the introduction of quick-freezing in this field would seem to offer very distinct possibilities for an improved product. The method may also add to the list of edible offal now exported from Australia. For instance, there is said to be a considerable demand in Europe for sheep's brains, and it has been proved that there is no appreciable difference between the quality of quick-frozen and of fresh brains.

4. Limitations of the Method.

There are five real, but not insuperable, difficulties which may hinder the export of quick-frozen cuts.

(*a*) With the present equipment, it is impossible to maintain constant temperatures at or below 0° F. in the holds of overseas vessels. For vessels equipped with ammonia or multiple-effect carbon-dioxide compressors, this temperature could probably be maintained, even in the Tropics; but, at present, the majority of vessels are equipped with simple carbon-dioxide compressors which cannot maintain temperatures below 10° F. during the voyage through the Tropics.

(*b*) The cost of maintaining a constant temperature of 0° F. in land stores is very great.

(*c*) In the butchers' shops throughout Great Britain and Europe, there are few refrigerators capable of maintaining temperatures below 20° F. In the absence of facilities for obtaining low temperatures for storage on land and overseas transport, it would probably be necessary to reduce the period of storage to a minimum, a procedure which, for Australia, would prevent a steady supply on the overseas markets being maintained.

(*d*) Despite the claims of several patentees of apparatus for quick-freezing, it is probable that the rates of freezing so far attained in "cuts" of beef exceeding 1 inch in thickness, are insufficiently high to prevent entirely the formation of "drip" and loss of normal texture when the meat is thawed. This consideration, however, does not apply to cuts of similar size from carcasses of lamb, mutton, and pork.

(*e*) There will probably be a distinct difficulty in disposing of the poorer cuts of beef which, normally, would not be packaged and quick-frozen.

Although the application of quick-freezing methods to the preservation of meat would seem to hold distinct possibilities for the Australian exporter, it is obvious that extensive, detailed investigations into the storage, transport, and marketing of the "cuts" are necessary before they could be placed on the British and European markets in a uniformly satisfactory condition.

5. Quick-frozen Fruits.

(*a*) *General.*—The cold storage of many foodstuffs has enabled what were once seasonal supplies to be made available to the consumer throughout the year, but, up to the present time, most vegetables and berry and stone fruits have only been available in the fresh condition and for a relatively short period during each year. It is interesting here to quote a statement made by Professor Stiles* :—

> ". . . We can group foods preserved by low temperatures into two classes :—
>
> (i) The temperature of cold storage is kept at 0° C. (32° F.) or higher (rarely a little lower), so that the physical state of the fresh material is maintained during storage. Examples of foods commonly preserved in this way are fruit and chilled beef.
>
> (ii) The temperature of cold storage is kept well below the freezing point of the food substance so that this becomes frozen into a solid block, and the physical condition of the material is profoundly altered. Examples of foods commonly preserved by this method are mutton, rabbits, and certain species of fish, as for example, salmon.
>
> While all foods can be preserved for a certain time by the first method, the second method has so far been applied satisfactorily to comparatively few food substances. Where it can be applied it is, however, much superior as a method of preservation, for the rate at which the chemical changes which cause deterioration of the tissue to take place is much reduced by the lower temperature, and such actions which take place in aqueous

* British Food Investigation Board Special Report No. 7 (1922), p. 7.

media are practically inhibited, while the solid state of frozen tissue also inhibits the growth of micro-organisms, or reduces greatly their rate of growth. For this reason, frozen material can be preserved in cold storage for a much longer period than the same material held in the merely chilled condition. . . . Hence it is obvious that one of the objects of scientific investigation should be to discover means of transferring as many food substances as possible from the first group to the second."

The duration of the period of storage of most vegetables and berry and stone fruits in the chilled condition is very limited. It was apparent, therefore, that methods would have to be devised to enable these foodstuffs to undergo the processes of freezing, storage, and thawing, without affecting appreciably their colour, flavour, and texture.

For a number of years, berry fruits and cherries have been frozen slowly in barrels with, and without, the addition of cane sugar, and then stored for long periods. Such fruit has been used chiefly for culinary purposes and by manufacturers of ice cream. This method of preservation, however, has been sufficiently long in use to ensure that the technique has become generally known.* While it marked a distinct advance in the technique of cold storage, there was, as yet, no method available for the continued preservation of vegetables and berry and stone fruits so that they reached the consumer in a condition closely resembling the fresh products. Recently, however, the methods of quick-freezing have been applied to the preservation of most berry and stone fruits, fruit juices, and many vegetables, and, while in most cases the resulting products are by no means perfect, sufficiently encouraging results have already been obtained to warrant careful consideration being given to this interesting development.

It has been difficult to ascertain the number of works engaged in the United States of America in the quick-freezing of fruits and vegetables, but, as far as can be determined, the chief packing plants are situated at Hillsboro' in Oregon, and Montezuma in Georgia, the former plant freezing cherries, berry fruits, and vegetables, and the latter freezing peaches.

(*b*) *Packing.*—The berry fruit are hulled, cleaned, graded to exclude all but the best and soundest berries, and packed in waxed cartons holding small quantities of fruit of the order of 1 lb. In order to facilitate packing, the peaches are sliced and packed in cartons holding from 1 to 2 lb. of fruit. It is usual now to add sufficient syrup to cover the slices, since exposure of the flesh to the air leads frequently to oxidative browning.

Prior to packing many vegetables, blanching with "brine" (sodium chloride) is apparently necessary in order that the colour may be preserved during the subsequent storage.

Considerable success has been attained with the production of quick-frozen fruit-juices, such as orange and grape-fruit. This juice is first filtered to remove all fibrous material, frozen in large blocks, and later cut into smaller blocks suitable for packing. At the present time, the following fruits and vegetables are being dealt with on a commercial scale:—Cherries, strawberries, raspberries, loganberries, peaches, peas, spinach, and asparagus; while sliced French beans, tomatoes, blueberries, and sliced apples have been treated on an experimental scale.

* A useful summary of this method of preservation is given in Technical Bulletin No. 148, U.S. Department of Agriculture, Washington, D.C.

(*c*) *Freezing.*—At the Hillsboro' plant, the packaged fruits and vegetables have been frozen by the Birdseye method, details of which have already been given. At the Montezuma plant, the peaches are frozen (in packages) in a machine which is equipped with belts passing over brine tanks, indirect contact with the brine on one side of the package only being secured. Details of the machine, and the temperature of the brine employed, are not yet available.

(*d*) *Storage and Transport.*—Fruit and vegetables undergo changes in texture and colour much more readily than does meat, and it has been found that the temperature of storage should be maintained below 0° F., preferably at — 5° F. At the latter temperature, storage may be continued safely for periods up to a year in duration. A rise of temperature beyond + 15° F. continued for any length of time is fatal. It is necessary, therefore, to take extreme precautions in the transport of these products. As mechanically refrigerated railroad cars have not yet been used on a large scale in America, solid carbon dioxide—" dry-ice "—has been used extensively to cool quick-frozen fruits and vegetables during transportation.

(*e*) *Quality of Products.*—The varieties of each particular fruit and vegetable which may be quick-frozen and stored successfully are very limited in numbers. For instance, only two varieties of peas after treatment will remain firm and retain their colour and flavour after cooking, and these two varieties, strange to say, have been considered to be unsatisfactory for the purposes of canning.

When the frozen fruit or vegetable is to be cooked immediately after its removal from storage, the quality of the resulting product probably does not differ appreciably from that of similar, cooked, unfrozen material; but, when it must be thawed, the texture of its flesh is seldom perfect after the completion of thawing. For instance, the flesh of quick-frozen strawberries which had been stored for six months underwent partial collapse and slight loss of juice after thawing.

By far the most serious difficulties encountered in this field have been the distinct losses of flavour and colour. These defects, however, have been partly remedied by—(*a*) a careful selection of the particular variety of each berry, stone fruit, and vegetables undergoing minimum losses of colour, and flavour, and texture; (*b*) taking precautions to ensure that the wrapping of the cartons is air-tight; and (*c*) storage at very low temperatures.

While this method for the preservation of fruits and vegetables is still in its infancy, and, perhaps, may not supply a distinct need when similar satisfactory canned goods can be obtained, it would seem to have distinct possibilities for enabling certain varieties of fruit to be available for consumption in the raw state, at times of the year remote from the months of production. It may, therefore, be of limited value in Australia for supplying a home demand.

The Imperial Geophysical Experimental Survey.

Review of Its Final Report.

By Sir T. W. Edgeworth David, K.B.E., F.R.S., &c.

The review that follows has been very kindly prepared by Sir T. W. Edgeworth David, K.B.E., C.M.G., F.R.S., B.A., D.Sc., Professor-Emeritus of Geology in the University of Sydney. It is expected that the printed copies of the report to which the review refers will be available in Australia towards the end of June next. They will be distributed through the commercial bookselling agencies, the published price in Great Britain being 15s. As pointed out by the reviewer, the report is such that it can be used as a text-book of prospecting by geophysical methods as well as an account of the investigational work carried out by the Survey in Australia.—Ed.

The above important work, now going through the University Press, Cambridge, is edited by A. Broughton Edge, the Director of the I.G.E.S., and Professor T. H. Laby, F.R.S., of Melbourne University.

The application of geophysical methods to prospecting for metallic ore bodies and underground structures favorable for the occurrence of oil or coal have met with marked success in Sweden, Germany, the United States, South Africa, and many other countries. In the Texas region of the United States, in one year alone (1925), as many as five underground salt domes associated with mineral oil were discovered and accurately located by geophysical methods. It is obvious that no nation which claims to be up to date in its methods of developing mining can afford to neglect such means of modern science to the above end.

It is not too much to say that the results of the two years' work done in Australia have on the whole exceeded our expectations, and are full of promise for the future.

When in England, in January, 1927, Mr. H. W. Gepp, Chairman of the Australian Development and Migration Commission, proposed to the British Government that geophysical methods of prospecting should be applied to certain areas of Australia with a view to aiding mining and encouraging the settlement of population. The proposal was subsequently submitted to a Sub-committee of the (Imperial) Committee of Civil Research, of which Sub-committee Sir Matthew Nathan, a former Governor of Queensland, was Chairman. The Sub-committee recommended that, in the interests of the Empire generally, Australia be chosen as the special part of the Empire where geophysical methods of prospecting should be tried.* The British Government, through the Empire Marketing Board, agreed to contribute half the cost of the work, the Commonwealth Government finding the other half.† The body set up to carry out the work was known as the Imperial Geophysical Experimental Survey (I.G.E.S. for short).

The object was to try out the best physical methods as thoroughly as possible in the course of two years' field work, and at the same time to instruct young Australian scientists in the theory and practice of the methods, and in the correct use of the various delicate instruments employed. Mr. A. Broughton Edge, who had been signally successful

* The report of this Sub-committee was published by the Empire Marketing Board (G.B.), see E.M.B. 6, Nov., 1927. For a fuller account of the early history of the I.G.E.S. see this *Journal*, Vol. 1, pp. 127, 292.

† Under the *Geophysical Prospecting Act* 1928.

in locating ore bodies concealed under alluvium in Rhodesia by the electrical method, was chosen as the Director of the Survey, and later a distinguished physicist, Dr. E. S. Bieler, of McGill University, Canada, was appointed Deputy Director.*

The Survey was controlled by a Geophysical Executive Committee, and its administrative details were attended to by the Council for Scientific and Industrial Research, with its head-quarters in Melbourne, while the laboratories and workshop of the Physics Department of Melbourne University were made available for testing and repairing the instruments used by the Survey. Field work commenced in Australia early in 1928, and was completed in February, 1930. Professor T. H. Laby, of the above Department, also became consultant physicist to the Survey.

Here the point should be stressed that, in order to secure the best results for a geophysical survey, it is most essential that a geological survey should precede it, for obviously it is of little use applying even the most reliable of geophysical tests if the country is geologically unsuited for the occurrence of such economic minerals as it is the object of the geophysical survey to discover. Also, in the interpretation of the geophysical evidence the co-operation of the geologist is indispensable if the best results are to be obtained.

In the following comments one has been especially helped by Major E. H. Booth, of the University of Sydney Physics Department, who has done not a little to improve seismic methods of research, and one has been aided by the advice of Professors Vonwiller and Cotton, by Mr. E. C. Andrews, Government Geologist of New South Wales, and the geophysicist to the Geological Survey of New South Wales, Mr. J. M. Rayner.

The primary purpose of the Survey being to test methods rather than to open up new fields—the latter a result which it is confidently hoped will follow later—choice had to be made of (i) areas suited to the application of more than one geophysical method; (ii) areas where the degree of accuracy of the geophysical survey could be practically tested by boring or sinking shafts, or reference to an adjacent, already established, mine or bore; and (iii) areas which in the aggregate furnished as much variety as possible in the nature of the minerals for which it was intended to prospect, as, for example, metallic minerals, coal, oil, graphite, water, &c., as well as variety in the climatic and other geographical conditions of the area to be tested.

Even before the success of the geophysical methods was assured by the actual experiments in Australia, so convinced of the economic importance of such tests was the Department of Mines of one of the States (New South Wales) that it took the offered opportunity of attaching to its geological staff a young physicist, J. M. Rayner, who spent his time with different field parties in turn, and thus gained invaluable experience of the methods employed. Actually, owing to the rapid change in economic conditions, New South Wales is at present the only State actively continuing geophysical prospecting, and it is doing so with quite satisfactory results. Moreover, that State has a nucleus for the formation and the supervision of other geophysical prospecting parties, the Department having purchased some of the equipment of the I.G.E.S.

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* The deeply to be deplored death from pneumonia of this eminent Professor, at Geraldton, in Western Australia, on the 25th July, 1929, was a very severe loss to the Geophysical Survey, no less than to science throughout the World.

The chapters of the report edited by A. Broughton Edge and T. H. Laby are allotted to sections dealing with the magnetic, electric, gravimetric, and seismic work. Sonic work was not attempted, as at the time it was considered that its results were not satisfactory.

By the division of the book into two parts, a sound but elementary discussion of the methods is given in the first part, comprehensible to the reader with a general elementary scientific training; while for the reader who desires to know very much more of the pure and applied theory, and of the details of procedure, the second part is available.

The Magnetic Method.—If free to rotate and take up a position in any plane, a compass needle points in different directions in different countries and in different parts of the same country. A needle can be mounted on axles, so that it forms a magnetic balance —free either to move in a horizontal plane or in a vertical plane. It is then called a magnetometer, or, if only a variation in the horizontal or vertical pulls on its poles is required, a variometer. If a big area were available (say a square mile) quite free from any local magnetic matter in the ground, a vertical variometer might be so adjusted that its compass was horizontal, when lying at right angles to the plane through the magnetic north and south, and it would remain horizontal over the whole area. If, however, there were any magnetic materials buried in the area, they would produce a "local anomaly" in their vicinity, one pole of the compass needle would be pushed up and the other pulled down, so that the balance would be upset. In its magnetic surveys with a vertical variometer, the I.G.E.S. was comparing vertical pulls on the poles of its balanced magnet from point to point, and seeking "local anomalies" to interpret in terms of underground magnetic deposits and rock materials. Two different types of instruments were employed:—A very sensitive Schmidt vertical balance, which could detect variations of one ten-thousandth of the normal value of the vertical attraction, and on which the Survey reports very favorably; and a Thalen-Tiberg magnetometer for employment when a very much less sensitive instrument was desirable.

Fields investigated were—

(1) Gelliondale, over the Victorian brown coal deposits, in conjunction with the gravity survey. The results were satisfactory, and agreed with the Gravimetric Section's observations, as well as with the knowledge gained from the bore holes previously made, with one exception, viz., a position where relatively large magnetic anomalies were found. From an examination of the figures and a knowledge of local geology, a concealed basaltic intrusion was postulated (basalt is relatively rich in a magnetic material—magnetite). After the close of the survey, a bore was put down at this position by the State Mines Department, and solid basalt was struck at 9 feet, and the bore was still in basalt when it was discontinued at 14 feet. (This presence of material of such relatively high specific gravity was also confirmed by the gravity survey.)

(2) Gulgong (New South Wales), over the basalt-filled "deep leads."*—The shallow leads and portion of the deep leads, not filled with basalt, have been worked, and nearly half a million ounces of gold taken from them. Largely owing to the cost of exploratory drilling, the course of the leads beyond the known worked portions has never been

* A deep lead is an old buried river-bed, covered by a considerable depth of later deposits, &c.

traced, though the State Department of Mines has postulated their probable courses. The basalt is slightly more magnetic than the bed-rock (which is slate intruded in places by granite and diorite), so an examination of the vertical anomaly should enable the course of the basalt flows, and hence of the leads they occupy, to be determined. This work was found to be admirably adapted to the vertical variometer. A comparison of a magnetic traverse of a lead, at a position where it had been tested by a line of bore holes, showed an excellent relationship between the variation in magnetic vertical intensity and the width and thickness of the basalt across the section. (Since the Survey closed and the report was written, the New South Wales Department of Mines has continued the variometer survey of this field; the basalt flows have now been very extensively mapped, the agreement with known bores and shafts being excellent.)

(3) Renison Bell (Tasmania).—Here work was carried out in conjunction with the Electrical Section. The Thalen-Tiberg instrument was employed, the anomalies being large, variations up to as much as 10 per cent. of normal intensity being recorded. The subsequent investigations confirm the work of this Survey in a very satisfactory manner—massive pyrrhotite deposits being discovered and exposed as a result. Over much of the field the results were complicated, but a combination of the magnetic with the electrical survey proved most illuminating.

(4) Kadina (South Australia).—Here the Thalen-Tiberg instrument was used over about 4 acres, vertical intensities being measured to locate anomalies in the Moonta-Wallaroo copper field. The anomaly was big—as large as at Renison Bell—and was easily plotted. A shaft was sunk to 60 feet, where the anomaly was greatest, passing at that depth through schist containing a high percentage of magnetite. The Department of Mines of South Australia does not consider that there is even any indirect connexion between this occurrence and the copper mineralization of the district, so that the magnetic anomalies there are of no immediate use to it.

Observations were also made at Cooper's Creek, Victoria, over pyrrhotite ores, and at Chillagoe, in Northern Queensland.

Undoubtedly, the Magnetic Section seems to have confirmed the utility in Australia of the magnetic survey; however, as it pointed out, the interpretation of the results is not always straightforward. But a big area can be cheaply and expeditiously mapped; and, if the geological knowledge is not sufficient to explain the anomalies, a test bore at the most interesting part of the anomaly will clear the matter up. There seems to be no doubt that a variometer survey is a very valuable adjunct to a geological survey.

The Gravimetric Method.—Two chapters are devoted to the gravimetric method. After much theoretical investigation and field experience, it would appear that this method has become one of the most reliable tools in the geophysicist's kit. Before proceeding to the field results, explanations are given which present with great thoroughness and lucidity the underlying principles of the method, descriptions of the instruments used, and the details of field procedure.

The principles of the method are probably well known, and may be summarized in elementary terms by saying that, at points on the surface of the earth above relatively heavy materials, the "pull of gravity"

becomes increased. This increase is very minute, but it can be readily measured by instruments of great sensitivity, recently developed. Conversely, above relatively lighter formations the "pull of gravity" becomes decreased. Thus, measurements taken at the surface of the earth can delineate the heavier and lighter zones beneath the surface, and, using these results, together with the available geological information, geophysicists can work out, given suitable conditions, the structure of a field for the purposes of a prospecting campaign. Two types of instruments were used by the Gravimetric Party—a large torsion balance, and its smaller modification, known as a gradiometer—and their performances are compared in the report. Generally speaking, the gradiometer was found to be the most suited to Australian conditions. Many useful hints in regard to field work are given, and typical problems, which the method has demonstrated its ability to solve, are mentioned. The method is used to greatest advantage when large scale structures, or deposits of considerable dimensions, are to be investigated. Although more exact than any of the other geophysical methods, the gravimetric work is much slower, so that during the course of the Survey it was only possible to carry out investigations on three fields.

One of the most striking pieces of work, in the whole of the I.G.E.S. report, is the description of the gravimetric survey of portion of the Gelliondale brown coal-field. The primary aim of the party was to compare the results of its tests with the results given by the numerous bore holes that had been put down in certain portions of the field. It was then intended to delimit the coal in parts of the field that had not been prospected. Maps, sections, and lists of bore holes, with the gravimetric measurements set alongside for purposes of comparison, show how successful the party was in achieving its primary aim. Without doubt, it was established that under the conditions at Gelliondale, where the coal lies at fairly shallow depths beneath a level surface, it is possible to outline the boundaries of the coal with great accuracy, and to determine the thickness and depth of the seam. In only one instance was there a serious disagreement between the gravimetric results and the bore-hole data. According to the log of this bore hole, bedrock was met at 73 feet, at a place where, according to the geophysical findings, bedrock should be at a depth greater than 200 feet. To settle the matter, an additional drill hole was put down on the site, and, although it had to be abandoned at a depth of 80 feet, still, by showing that bedrock was certainly not reached at that depth, it obviously confirmed the gravimetric result. Evidently the original bore hole had struck a large boulder, which had been mistaken for bedrock, an error not unknown in drilling experience.

Three other bore holes were subsequently put down by the Victorian Mines Department, to check the findings of the Survey party on other parts of the field, which had not been fully prospected. One of these bore holes was made at a point where the officers of the Geophysical Survey predicted bedrock at 100 feet with 50 feet of coal. Actually, the bore log showed bedrock at 98 feet with 62 feet of coal, thus proving the accuracy of what can only be regarded as a highly successful piece of prediction. Of the other two bores, one was put down at a point where the officers of the Gravimetric Party postulated the presence of a dyke, and the other in a region where the coal was considered to be thinning out. In both these cases the predictions were amply verified. If everything be taken into consideration, it would appear that the work

of the Gravimetric Section at the Gelliondale brown coal-field attained a measure of success comparable to anything which has been recorded in connexion with the solving of similar problems in other countries.

A brief survey was made in the vicinity of a line of bore holes at Home Rule, New South Wales. These bores have defined the position of a "deep lead," or buried river channel, carrying gold-bearing gravels, so that a good opportunity was afforded the Gravimetric Party to compare its results in this bore vicinity with the bore data. Over part of the area there was good agreement, but, otherwise, the gravimetric work seemed to show that underground conditions were much more complicated than would appear from the bore logs. In fact, a considerable body of evidence was obtained, indicating the presence of another and tributary lead which junctions with the main lead, in the vicinity of the line of bores. Certainly it was established that the deep lead, of which there are many in New South Wales reasonably suspected of carrying tin or gold-bearing wash, is a structure which is highly suitable for prospecting by the gravimetric method.

A further survey was carried out at Lakes Entrance, in Victoria, where it was hoped to determine the presence of a structure suitable for the accumulation of oil. No positive evidence for such a structure was found, but a relatively small area only was covered by the Survey.

The Electrical Methods.—A considerable portion of the report deals with the work carried out in connexion with the electrical methods of prospecting. Two field parties were equipped. Electrical methods of prospecting mineral deposits have been proved highly successful in many parts of the world, and the primary aim of the Electrical Sections was to determine whether or not these methods were applicable under Australian conditions. The electrical methods used by the Survey have been dealt with under five headings—(1) the spontaneous polarization method, in which the oxidation of a sulphide body leads to its own detection, making external excitation unnecessary; (2) earth resistivity methods, wherein the electrical resistance of large volumes of ground is measured with a view to determining depth to the water table, bed-rock, &c.; (3) equipotential line methods, which locate ore bodies by determining irregularities in the flow of an alternating current through the ground; (4) potential ratio methods, which accomplish results similarly to (2) but more efficiently, owing to the development of special apparatus by the Geophysical Survey; (5) the electromagnetic methods, which determine the presence of ore bodies by passing electromagnetic fields of varying intensities down into the ground.

During the course of the Survey's operations a very considerable body of data was collected on the possibilities and limitations of the various methods. The electrical methods are used chiefly in the prospecting of metalliferous deposits, and it was found that, corresponding to each method, there were geological conditions under which it operated most successfully. Generally, several methods were tested over the same ground, and, under favorable conditions, the whole was checked by a magnetic survey. Inquiries are frequently made concerning the greatest depth at which an ore body could be detected by electrical methods. This figure, of course, depends upon a number of factors, but generally was found by the I.G.E.S. to be of the order of a few hundred feet, ranging from 200 feet for moderate-sized ore bodies to 500 feet for very large deposits. The statement, which has been made before, that the maximum depth at which an ore body can be detected is about half its strike length, was found to be a fairly useful working rule.

In New South Wales, work of a purely experimental nature was carried out at Anembo, Captain's Flat, and Gulgong. It may be added that, at Anembo, in the neighbourhood of a line of gossans, a limited region of high conductivity was located, which might well be due to sulphide ore. A much more extensive piece of work was done at Leadville, where the equipotential, electromagnetic, and spontaneous polarization methods were tested. The agreement between the geophysical results and the disposition of the ore bodies, as known from mine workings, was generally good, and in some cases very striking. During the course of the work indications were obtained of the existence of a few mineralized zones that had not been prospected hitherto. On one of these zones a bore was subsequently put down by the Department of Mines, and, after passing through over 100 feet of soft gossan, it encountered two bands of lode material, close together, and each 2 feet in thickness. Although no satisfactory ore body was developed, the results may be claimed as a technical success, and the opinion was expressed by the Chief Inspector of Mines that it is quite probable that a sulphide body underlies the gossany material at a greater depth.

In Tasmania, where some of the Survey's most outstanding results were obtained, three fields were selected—South Zeehan, Renison Bell, and the North Zeehan copper-nickel field. At Renison Bell, the equipotential, electromagnetic, and spontaneous polarization methods were all applied in an attempt to delimit sills of tin-bearing pyrrhotite, the work being checked by an extensive magnetic survey. A large number of drill holes had been put down on this field, but their logs were withheld from the Geophysical Survey staff until the completion of their work. In the report under discussion the results of the tests and the results of the bore holes are set down side by side, so that it requires only a glance to see the high degree of correlation which exists. On the North Zeehan copper-nickel field a pyroxenite dyke cuts across country, and ore bodies of copper-nickel have been worked at a few points. It should be pointed out that ordinary methods of prospecting would not have availed in this locality owing to the swampy nature of the country and the dense undergrowth. The dyke was followed, the equipotential, potential-ratio, and high-frequency electromagnetic methods being employed until marked indications were encountered, which were interpreted as mineralized zones. The findings were subsequently checked by the Tasmanian Mines Department, and several sulphide bodies proved. One of these was penetrated by a diamond drill, the ore assaying from 9 to 11 per cent. nickel and 4 to 9 per cent. copper, a richer ore than has hitherto been mined on the field.

Two very different types of deposit were prospected in South Australia—(i) the copper lodes of Moonta, and (ii) graphite bodies near Port Lincoln. At Moonta, the equipotential, potential-ratio, and high-frequency methods were used, but it soon appeared that, owing to the high conductivity of the surface layers, the locality was not suitable for the electrical methods employed. At Port Lincoln, the equipotential and potential-ratio methods were used in the search for new bodies of graphite in the neighbourhood of working mines. Marked indications were obtained, one of which was checked and found to be due to a large new body of graphite about 52 feet thick.

Results in Western Australia, where only the equipotential and potential-ratio methods were used, are felt to be rather disappointing

in that no new bodies of mineral were located. Considerable difficulties were encountered owing to the high salinity of the underground waters; but, on the other hand, valuable data were obtained concerning the adverse effects of these conditions.

On the Chillagoe copper-field, in Queensland, it was established that the electrical methods used (equipotential and potential ratio) are highly suitable for prospecting under the geological conditions met in that area. Work was carried out on two areas—Redcap and Griffiths—and subsequent drill holes have proved the existence of a low-grade copper body beneath one of the party's indications on the latter site.

The Seismic Section.—Very little information was available as to seismic methods when the Survey first started, and neither experienced operators nor the necessary equipment were obtainable, outside one or two commercial geophysical companies. A year later, the Australian Committee of the Institute of Physics drew attention to the fact that one of its members, on a University staff in Australia, was familiar with the pure theory, and with such knowledge of applied work on seismic prospecting as had been published, and had for some years been carrying out experiments by an electrical recording system, similar to that recently adopted by a geophysical company. The Executive accordingly decided to form a section even at that late stage, and within two months equipment to supplement that already in Australia for electrical recording, and a standard field seismometer, of the mechanically recording type, ordered by cable, had arrived, been tested in the laboratory, and were in the field at the disposal of the field party.

In this method, a charge of explosive is buried in the ground at a chosen point, and is fired electrically. Recording instruments at surveyed points pick up the arrival of shocks through the earth, and by suitable means the instant at which the explosion takes place, and the instants at which the first and subsequent earth tremors arrive at the recording instruments, are recorded on a moving film, automatically marked with a time scale. If the underground materials were homogenous and the instruments spaced at uniformly varying distances from the point of explosion, the first shocks to reach each instrument would occur at uniform time intervals, proportional to their distance from the explosion.

The same type of ground wave will travel through different materials with different velocities; for instance, the first wave to arrive through wet loam travels with a velocity of 2,500 feet per second, whereas its velocity through granite is 18,500 feet per second. It is upon the fact that earth waves travel with different velocities through different materials that prospecting by the seismic method is based. Suppose, for instance, it were desired to trace out the path of a basalt dyke concealed but coming quite close to the surface of the ground, then, if the line along which the recording instruments were placed ran partly along the dyke whilst crossing it obliquely, an examination of the recording film would show the ordinary velocity for the waves travelling through, say, shale (10,000 feet per second) on either side of the dyke, and a velocity much higher than that (basalt 20,000 feet per second) between the two or more recording instruments that were on the basalt. (With the electrical recording and registering system employed by the Seismic Section of the I.G.E.S., six detectors were employed simultaneously.) Having thus found a point on the basalt, that is then made an explosion point, and detector lines are "fanned" out from there—

that is, for successive explosions they would be set out upon lines diverging from the same explosion centre. Whilst a line is over the basalt, the instruments record high velocities; when it crosses off into the surrounding material, the velocities decrease. So the line along which most instruments record a basalt velocity runs most nearly along its course. The furthest point along this line, to which the velocity is observed as that in basalt, is now taken as the new explosion point, and the experiment is repeated and extended. This procedure is referred to as "fanning." For surface velocity work, the Seismic Section found quite small charges of explosive sufficient—of the order of five plugs (½ lb.) of blasting gelatine for a ½-mile line, even in such poor conducting material as argillaceous sand.

If the feature be at some considerable depth below the surface, the application is equally direct, though the observations and calculations are not so simple. In that case, the detectors nearer the explosion record the ordinary slower velocity corresponding to the upper strata; then beyond a certain distance from the explosion the instruments record a much feebler wave coming in ahead of calculated time—and the further out one goes over a uniform structure the sooner it comes in ahead of the time calculated for velocity in the overburden. This is the wave that has gone to the lower strata, travelled along it with higher velocity, and come up to the surface again, the higher speed in the lower strata more than compensating for the extra distance it has traversed. For many simple structures the calculations are quite straightforward. The geophysicist requires to know the time of arrival of these "first arrivals," and the time of the explosion, both of which are obtainable from the film record. It will be seen that the most important part of the work is a knowledge of the velocity of the waves through different materials in the earth crust. The published figures were most contradictory, Now, however, the Seismic Section has determined the velocity of earth waves in a wide range of materials, and the figures are tabulated in the report.

Owing to the short time at the disposal of this Section, only two centres were visited. The first position was at Home Rule, near Gulgong, over a site where a deep lead was indicated. The Section found the calculated depth to bedrock, over the lead itself, agreed well with the bore results; but the north-east bank was not so steep as indicated by the bores, whilst the south-east bank did not exist where shown by the bores. The criticism would seem to be that the method was satisfactory for a general feature, such as the undulating bedrock of the lead, but failed to disclose the smaller scale details of the banks correctly. But subsequent investigations by the Section, further up stream, disclosed two channels, which would appear to converge just where the first traverse was made; as the bores were not in line but varied by up to 15 feet from line, it is possible that the Seismic Section fortuitously came on to the junction of two streams. The gravimetric survey across the "line" of bore holes also indicated that the section was not so simple as had been deduced from the original boring, there being definite indications of the junctioning at that point of a second lead, which the bore holes just missed. To check the position of this second lead, two other gradiometer surveys were run across its assumed path of the "new" lead—and they show it to be even slightly greater in depth than the "old" main lead crossed by the lines of bores.

"Fanning" along the lead was found to be quite practicable; there was only time to trace one branch of the lead for a short distance to indicate the practicability of the method for deep leads.

(Subsequent to the close of the Survey a magnetic survey has been made over some 8 square miles of this district, near the line of bore holes; it has disclosed a very big anomaly, the structure at the vicinity of the line of bores not being nearly so simple as was anticipated when the Seismic Section went there first. The results of this research are now ready for publication.)

The second centre was at Tallong, also in New South Wales. This centre was chosen because, being the site of numerous and regular geological excursions from the University of Sydney, its geology was well known; also, it combined in one small area a large number of different rocks of different geological ages. Rock and earth velocities were measured, and traverses were made, so as to pass from formation to formation. The results are very satisfactory, and in general agreement with those anticipated from the geological surveys, though extending the knowledge of the buried junctions and overlappings.

It must be remembered that the seismic method indicates the nature and disposition of underground masses and formations; it does not indicate what minerals, oil deposits, &c., are actually present. This section of the I.G.E.S. employed small charges, and did not examine depths beyond 300 feet, as they were limited by consideration of time, field strength, and finance. But, given bigger charges and bigger scale work, the system should be readily adaptable to greater depths. Claims have been made to depths of 8,000 feet. There is no doubt that major formations at depths of several thousand feet can be mapped.

In the course of his seismic experiments in detecting underground structures, Major E. H. Booth has evolved a new type of hot-wire seismograph. This can be buried a few feet underground, so as to avoid local tremors in the earth's surface caused, for example, by wind. The following are important advantages of the hot-wire microphone:—(i) It is perfectly steady, free from internal disturbances; (ii) it is simple and cheap; (iii) the same external movement produces the same record every time; and (iv) it is sensitive, but, if extreme sensitivity is required, it can, like the electrical detectors, be employed with any stage amplification.

The Future of Geophysical Prospecting in the Commonwealth.—The results of the two years' work in Australia have shown that for our requirements the more rapid and more approximate methods of geophysical prospecting should precede the slower and more precise methods.

The seismic, the magnetic, and the electrical methods are all much more rapid than the gravimetric. The seismic method is likely to prove of great value in tracing out "deep leads" of alluvial gold or tin, whether the lead be entirely alluvial or whether it be alluvial covered with basalt.

In Eastern Australia there are very numerous areas where the exact position of the payable channel, or "gutter," has been lost. The seismic method is full of possibilities for picking up the continuation of such lost deep leads, as well as in finding new leads. This last remark applies specially to the unproved deep leads of Western Australia, such

as the one which must underlie Lake Raeside and Lake Cowan, and others of the elongated lakes, which mark the site of silted-up old river channels.

In the case of large formations, where the speed of the seismic waves varies from 2,500 feet a second (wet loam) up to about 18,500 feet a second (granite), it should be possible to determine the underground plane of junction of such formations to a depth of several thousands of feet below the surface by the seismic method. This method may prove of great value for, for example, determining the thickness of alluvial deposits over the bedrock in the great delta and vast alluvial plains of the Fly River, and other rivers, in Papua, which meander across this 100-mile wide plain. There can be little doubt that under the alluvials of this great plain are, in places, what will eventually prove to be payable oil-fields. What is needed is some reasonably cheap, and relatively rapid, method of locating suitable structures, such as ridges or domes in the bedrock strata, likely to carry mineral oil.

The seismic method as well as the magnetic method might well be applied to the important problem of locating concealed hills, ridges, or domes in the bedrock forming the floor of the Lakes Entrance oil-field in Victoria. If such structures can be located, they should offer the best chances for prospecting for a flowing oil-field. Already over 15,000 gallons of oil have been won from the above oil-field. Once a suitable underground structure has been approximately located by the seismic and magnetic methods, more precise information can be gained by the application of the gravimetric method, and, in view of oil being strongly dielectric, the electric method might help also.

The magnetic method might be used in combination with the seismic methods in the above work, though it can hardly be expected to yield such positive results.

The electric method may possibly be used at a later stage, as well as the gravimetric method, in the attempt to locate more accurately the position of the concealed ridge or dome.*

In regard to the locating of underground water supplies geophysically, experiments in the Mallee country of Victoria show that the problem is complex, and there has not yet been time to try out the different methods at all fully with a view to locating water-bearing horizons.

The location at Renison Bell, Tasmania, of a nickel-bearing magnetic pyrites deposit by means of the geophysical electric method was a triumphant demonstration of the usefulness of the method.

Obviously, there must be a vast number of sulphide ore bodies as yet undiscovered in Australia, Tasmania, and New Guinea, in areas like those of Chillagoe, Cloncurry, Mount Isa, Lawn Hills areas in Queensland; Broken Hill, Captain's Flat, &c., New South Wales; Bethanga, Cassilis, Cooper's Creek, Thomson River, Mount Deddick, &c., Victoria; Read-Rosebery, Renison Bell, Zeehan, &c., Tasmania.

In South Australia there must be numerous bodies of copper-bearing pyritic bodies as yet undiscovered, particularly in the belts of limestone, like that at Burra, and though saline waters and the presence of magnetite in the country rock have proved disturbing factors for the geophysicist at Moonta, there is little doubt that, in the near future, combined geophysical methods will reveal some of this hidden wealth.

* The point should be again stressed that, wherever possible, careful geological survey should precede geophysical survey.

In Western Australia, in areas like Northampton, Wiluna, &c., there must be numerous pyritic ore bodies yet to be found. There can be no doubt that there is an abundant harvest to be reaped, and that the new reaping machine, this geophysical prospecting apparatus, provided it is constantly being brought up to date, and is in the hands of competent geophysicists, aiding the geologists, will prove effective, but some patience on the part of the public will probably be needed before marked success is attained.

As regards the present report itself, it should be added that it is fully illustrated with a very large number of diagrams. The Gravimetric Section includes a typical record sheet of a station observation, showing terrain and other connexions; the Seismic Section includes a detailed set of observations along one traverse, giving the actual time of first arrival at each station, for a "shoot" in one direction and in the reverse direction, and the underground section along that path; certain of the Electrical Section's methods are given also in working details; in a book which will serve as a text-book for the field workers as well as for the physicist, geophysicist, and geologist, such details are invaluable. It is to be regretted that such a detailed record of a traverse, showing the corrections and final result, is not given in either part of the report of the Magnetic Section. Far more competent critics than oneself have commented as follows about the report:—The report is "an impressive record of work, which was very creditable to all concerned, especially having regard to the difficulties which had to be overcome."—(British Department of Scientific and Industrial Research, London.)

Mr. E. Lancaster Jones, who has, together with his colleague, Captain H. Shaw, made such important contributions to geophysical survey work, states—"My general view is that the reports are very ably compiled. Those portions dealing with the theory and apparatus of each method, in detail, are by far the most comprehensive account I have yet seen, and will do much to clear up many discrepancies and doubts regarding these methods."

Captain Shaw, referring to the account of gravimetric methods, says—"The author is to be congratulated on the lucid exposition of the subject, and on the simple and original manner in which he has explained the behaviour of the instruments in Chapter II."

Professor A. O. Rankine, referring specially to the Seismic Section of the report, says—"I think the writers are to be highly congratulated on the report which they have presented. It is written with clarity and elegance, and I have found it eminently readable."

One may fairly claim for this report that it is the most complete treatise on geophysical methods, for aiding the prospecting for economic minerals, that has ever been published, and the editors and their coadjutors are to be warmly congratulated on their book, no less than all those who have been actively engaged on the geophysical survey, and have faithfully and efficiently performed their historic piece of work for the economic benefit of the Commonwealth, no less than for that of the British Empire, and for the advancement of geophysical research throughout the world.

Liquid Fuels from Coal: Report by Dr. Rivett.

One of the matters to which the Government asked the Chief Executive Officer of the Council (Dr. A. C. D. Rivett) to give some attention during his recent visit to Great Britain and the Continent was the present position of investigations relating to the production of fuel oils from coal. Whilst abroad, Dr. Rivett was able to visit several centres of research, both governmental and private, where work on the problem was in progress. He was helped very considerably by the ready assistance and information made available to him by numerous people engaged in this special field, and was thus enabled to cover much more ground than would otherwise have been the case. Shortly after returning to Australia, he furnished the Government with a report, and the paragraphs that follow have been based on the contents of that document. The report itself consists of statements and conclusions by Dr. Rivett, together with two somewhat lengthy appendices. One comprises a report entitled "Costs in Liquid Fuel Production from Coal," by Mr. A. S. Fitzpatrick, M.Sc., Ph.D., who was, at the time of writing, a scientific officer attached to the Representative of the Council in Great Britain. The other appendix consists of a detailed report entitled "The Production of Liquid Fuels from Coal," by L. J. Rogers, B.E., a former Australian research trainee under the Science and Industry Endowment Act.—Ed.

In the introductory portion of the report, attention is drawn to the large amount of information that is now available as a result of experimental work aiming at the development of economically attractive methods of producing fuel oil from black and brown coals. It is also pointed out that, where commercial and financial interests are inevitably so prominent, an inquirer associated with a Government organization may find it necessary to be a little sceptical about some of the claims put before him, particularly when proper testing of them is impossible

The production of oils from coal is then discussed under the following headings:—

(*a*) Low temperature distillation of black coal;
(*b*) hydrogenation of black coal;
(*c*) low temperature distillation of brown coal; and
(*d*) hydrogenation of—(i) brown coal, and (ii) brown coal tars.

(*a*) *Low Temperature Distillation of Black Coal.*—Low temperature distillation of black coal is not at all a new subject; actually it was the method adopted in the earliest day of the coal-gas industry, and the modern high-temperature methods of that industry have been developed from it. About 600 processes have been tried during the last 125 years for low-temperature carbonization of various fuels. Three hundred are suitable for coal, and about half of these have some importance, and have been more or less under active consideration in recent years. In Great Britain, there are more than 40 processes, represented by 75 to 100 limited liability companies with a nominal total capital of £8,000,000. The semi-coke obtained from black coal by low-temperature distillation has approximately the same value per ton as the coal from which it was produced. Assuming a market for the coke, economic success, therefore, depends upon the distillation products being worth more than the costs of working added to that of their fraction of the original coal.

Claims of economic success have been put forward by private interests from time to time, but in no case were they found to be supported by a properly authenticated balance-sheet for a sufficiently large plant run for a sufficiently long time. The writer then proceeds:—"If now in England, where there exists a market and a need for smokeless fuel of the semi-coke type much greater than can be expected

in Australia for many years to come, economic success is quite dubious, it seems to me to follow inevitably that the prospects with us for low-temperature distillation processes for black coals must be regarded as negligibly small at present."

(*b*) *Hydrogenation of Black Coals.*—At the Billingham works of Imperial Chemical Industries Ltd., a 70 per cent. conversion of suitable black coal into liquid has been achieved in a 10-ton per day unit. Though many technical points call for further investigation, and though by no means all black coals may be hydrogenated, ample justification exists for the claim that the liquefaction of black coal by hydrogenation processes is now a technical success.

As to the economics of the process, these centre round the oil and tar values, the residual coal being of no special value. It is obvious that the treatment of coal under high pressure in expensive retorts, with costly pumps for circulation, can hardly be as cheap a process as obtaining crude oil ready made from the earth. A quantitative measure of the difference in production costs it would be difficult to assess. Two important factors so far as the hydrogenation process is concerned are, firstly, an appropriate size of plant (upwards of 250 tons per day), and, secondly, the association of the plant with other plants using hydrogen. Judging from experience elsewhere, hydrogenation cannot well stand by itself, and for economical manufacture close association seems essential with other industries, such as those dealing with carbon dioxide and synthetic ammonia. This is well exemplified in existing practice in Germany and Great Britain. As a matter of fact, it would be reasonable to say that the extent to which Australia can develop oil-from-coal manufacture is closely associated with the extent to which her farmers need, and use, nitrogenous fertilizers.

It is brought out incidentally in the report that, if Australia were to erect a plant to treat 500 tons of coal per day, the consequent increased coal consumption, even allowing for about five times as much for the production of requisite power, would amount only to a few parts per cent. of present production, and so not affect the coal industry to as great an extent as is sometimes assumed.

(*c*) *Low-temperature Distillation of Brown Coal.*—The economics of this process differ from those of the corresponding treatment of the black coal in that the solid product has a fuel value decidedly greater, weight for weight, than that of the initial material. In Germany, which is specializing on the distillation of brown coal, particular attention is being given to the coke produced. For briquetting, the binder problem is still a serious one, but Dr. Rivett was assured in Germany that a new chain grate has been devised on which brown-coal coke can be satisfactorily burnt without briquetting. In any case, it could, of course, be powdered and used as pulverized fuel.

In Australian States, where good black coal for steam raising is not cheap, and where extensive deposits of brown coal occur, the possibilities of brown-coal coke deserve close examination, provided that the liquid distillate can be made to carry a sufficient share of the costs of production.

(*d*) *Hydrogenation of Brown Coal Tars.*—This problem has been receiving considerable attention in Germany, where direct hydrogenation of brown coal (suspended in a suitable oil) appears to have been abandoned, temporarily at least.

The hydrogenation of brown-coal tars, however, is a much simpler process than that of the treatment of the solid material. The I.G. works at Leuna, Germany, are at the present time producing 300 metric tons of refined motor spirit per day from the hydrogenation, in both liquid and gaseous phases, of brown-coal tars obtained from surrounding works. The I.G. Coy, itself does not distil brown coal. Although it has been stated that the petrol produced can be sold profitably at 1s. 6d. per gallon, the economic position—which, by reason of the many complicated relationships of the I.G., is very involved—is apparently not entirely satisfactory, for, if there were good profits available, it seems unlikely that production would have remained as long as it has around the figure of 300 tons per day. In any case, so far as Australia is concerned, the hydrogenation of brown-coal tars is intimately bound up with the utilization of the brown-coal coke simultaneously produced with the tars.

(*e*) *Black or Brown Coal as Raw Material.*—On the question as to whether black or brown coal is the more desirable raw material under Australian conditions, it is stated that it is very debatable whether any one is able to give a sound answer as yet. Britain leads in work on black coal, while Germany possesses more information on brown coal. A pooling of this knowledge and a thorough discussion by competent people (technical and administrative) of the relative merits of the two possibilities are necessary. The report then proceeds to point out that such discussions are not so unlikely as might at first sight be assumed, for, apart from the general observation which any visitor to Britain and Germany cannot fail to make, that these two countries are steadily drawing closer together in industrial matters, it is common knowledge that the Imperial Chemical Industries of Great Britain and the Interessen-Gemeinschaft der Farben-industrie of Germany have for some time past been discussing the very type of association which may lead to the discussion indicated as necessary. In these negotiations the Standard Oil Co. of America also shares, and it is inevitable that the outcome of the conversations between these technically and financially powerful bodies will affect very definitely the immediate future of oil-from-coal work.

[Since the Report was written it has been announced that an understanding has been arrived at between the concerns named.—Ed.]

(*f*) *Distribution Problem.*—Attention is drawn in the report to the problem of distribution that would arise if any motor fuel were produced from coal in Australia. It is well known that distribution is not merely important, but in the extra urban sparsely populated and huge areas of Australia it is a very serious item of cost. Due consideration of the fact that the existing oil companies have already installed adequate, if not far more than adequate, facilities for this important process is thus desirable.

(*g*) *Summary of Conclusions.*—The summary of conclusions contained in the report is as follows:—

(1) Low-temperature distillation of black coal does not at the present time offer attractive economic possibilities in Australia.

(2) The preparation of crude oil by the hydrogenation of black coal is technically well developed, but cannot compete economically on equal terms with the obtaining of natural oils from the earth. There may, however, well be other considerations which make it worth while, from a Commonwealth point of view, to encourage the coal work, despite the economic conditions attaching to it.

(3) Low-temperature distillation of brown coal yields a coke of considerably higher value than the initial material. In those parts of Australia where brown coal deposits are considerable, the production of this coke merits earnest attention. Judging by German practice, the tars are valuable as raw material for hydrogenation to fuel oils.

(4) In order to keep down the costs of the finished product, the oil from coal industry, if developed at all, must be on a large scale. Its almost inevitable association with other industries using hydrogen and carbon dioxide means that many other considerations must be taken into account than those which are immediately obvious.

(5) Distribution of its product will be a big factor in an Australian oil industry, and the present entrenchment of the flow-oil companies in this respect makes it eminently desirable that their assistance be secured for any local development.

(6) I am of the opinion that the initiation and development of an Australian industry, if practicable, can best be effected by some such organization as the proposed, but not yet completed, association of interests of Imperial Chemical Industries Ltd., the Standard Oil Co. of the United States of America, and the Interessen-Gemeinschaft of Germany. It is desirable that close *liaison* be maintained between the Commonwealth Government and these bodies through their British member.

Portable Field Apparatus for the Estimation of Chlorides in Soils.

By R. J. Best, M.Sc., Waite Agricultural Research Institute, University of Adelaide.

Since 1929, the electrometric method of determining the amount of chloride in soils, as developed by the author[1] has been used exclusively in these laboratories. The greater simplicity and speed of the method make it very suitable for carrying out determinations in the field, and, at the request of Professor J. A. Prescott, the author designed an outfit for use on salt surveys. This apparatus has been thoroughly tested in the field, and has made possible the carrying out of accurate and detailed salt surveys on the spot.

The principle and technique of the method as used in the laboratory has been described elsewhere[1]. The field apparatus is represented in Plate 8, Figs. 1 and 2.

Description of Figures.

Figure 1.—This figure shows the apparatus prepared for transport. The case is constructed of five-ply maple, and is divided into two compartments. The unipivot galvanometer (Cambridge Instrument Company, Pattern A, Catalogue No. 41311, coil resistance 1,000 ohms) is mounted in the larger right-hand compartment. The smaller compartment on the left is fitted with a clamping device to hold two brass cylinders. These cylinders are lined with rubber and fitted with caps. One carries the reference electrode vessel, and the other a stoppered test tube full of water, containing the silver—silver chloride electrode.

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(1) "A rapid electrometric method for determining the chloride content of soils."—*Jour. Agric. Sci.* 19; 533, 1929.

This compartment also carries a rubber disc I (Fig. 2), connecting screws, flex, shoelace in a bent glass tube, and stirring rods. The uprights and clamps for holding the electrode system and burette are mounted in the lid, which is provided with a leather handle on the outside. The external dimensions of the case when closed are 8 inches x 6¼ inches x 4¼ inches high, and when ready for transport it weighs about 6 lb. The original outfit was constructed by the Physics Workshop of the University of Adelaide, while a further number are being constructed for use at various field stations.

Figure 2.—In Fig. 2, the apparatus is shown as it appears in use. The reference electrode is made of stout pyrex glass tubing, and measures 0.5 inches x 3 inches. This size makes it unnecessary to carry a large stock of buffer solution. The platinum foil electrode is sealed into the vessel by means of a strong piece of platinum wire. If desired, a separate platinum electrode sealed into glass tubing to pass through the stopper in the usual way may be used, in which case the wire should be taken right to the top of the tube and connexion made by means of a brass terminal. The vessel is half filled with chloride-free buffer solution, to which quinhydrone has been added.

The agar-saturated KNO_3 bridge is replaced by a round white cotton shoelace soaked in saturated KNO_3 solution. A connecting screw holds the Ag-Ag Cl electrode in position. Paraffined paper cups have been found to be very good substitutes for glass beakers. They may be used many times, and besides being robust, have the advantage that they are procurable in small country settlements, and are inexpensive enough to be discarded when a survey has been completed.

A useful set of field balances, measuring 7½ inches x 3½ inches x 2 inches, and weighing ¾ lb., was procured locally. When dealing with a large number of samples of similar sp. gr., a vessel marked at the 5 gm. level will greatly expedite weighing.

Reagents.

Standard Solutions.—For convenience during transport, the standard silver nitrate and potassium chloride solutions are preferably made up to 3.546 normal, and diluted to one-tenth this strength on the field. The distilled water obtainable at local garages may be used for such dilutions. If desired, the solids may be weighed out in the laboratory and placed into glass tubes and sealed, each tube containing sufficient material to make up a convenient quantity of reagent on the field.

Water for Preparing Soil Samples.—Rain water has been found to be satisfactory for preparing soil suspensions. At Barmera, South Australia, it was found necessary to apply a correction for the chlorides in tank water. Since the amount of chloride is small, and as the same quantity of water is used for each determination, this presents no difficulty.

Procedure.

The soil as taken from the field is air dried, sub-sampled, and crushed. A convenient quantity (depending on the amount of chloride expected) is weighed on to a counterpoised aluminium scoop. In most cases, 5 gm. is sufficient. The soil is transferred to paraffined paper cups (or other vessels), containing 50 ml. of water. The suspension is stirred, and after five minutes the titration is carried out, the soil being well stirred after each addition of reagent.

PLATE 1.

(Heavy and Light Cropping in Alternate Years—A Serious Defect of the Australian Apple Industry. See page 65.)

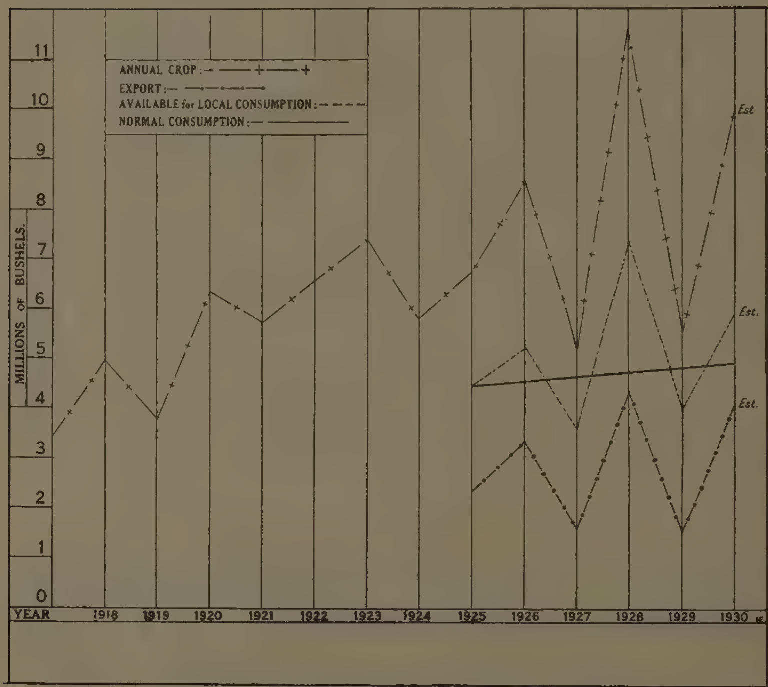


FIG. 1.—Graphs showing the fluctuations in Australian production, etc., of apples.

PLATE 2.

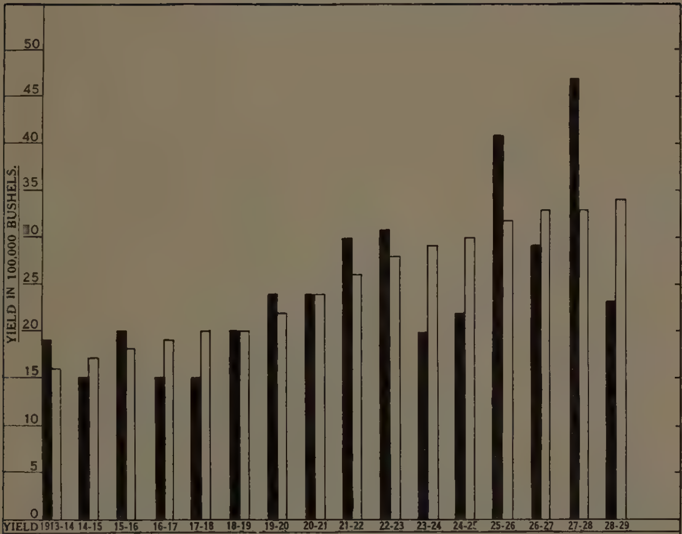


Fig 2.—TASMANIA.

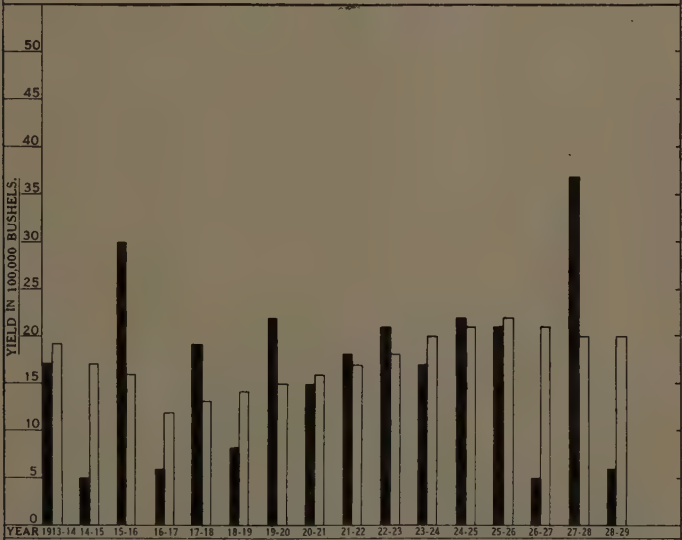
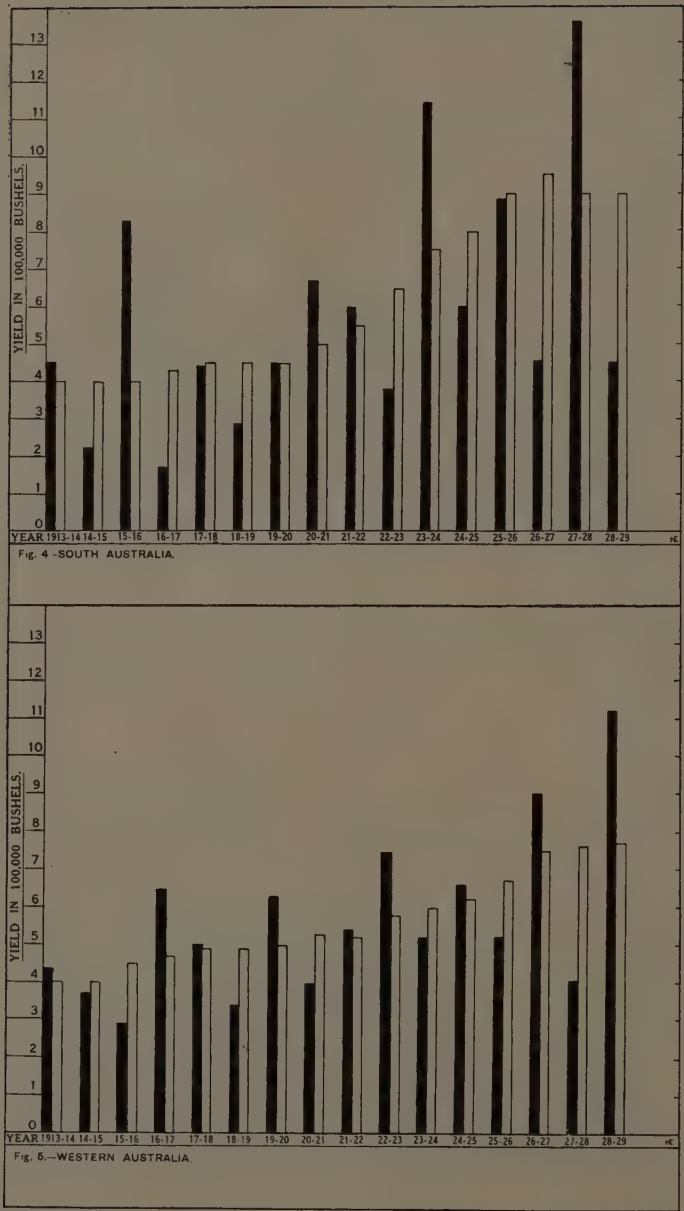


Fig. 3.—VICTORIA

FIGS. 2 AND 3.—Diagrams representing the annual production and normal yield of apples in Tasmania and Victoria since the year 1913–14.
Production = heavy line. Normal yield = white line.

PLATE 3.



Diagrams representing the annual production and normal yield of apples in South Australia and Western Australia since the year 1913–14.

Production = heavy line. Normal yield = white line.

PLATE 4.

(A Soil Survey of the Bed of Lake Albert. See page 83.)

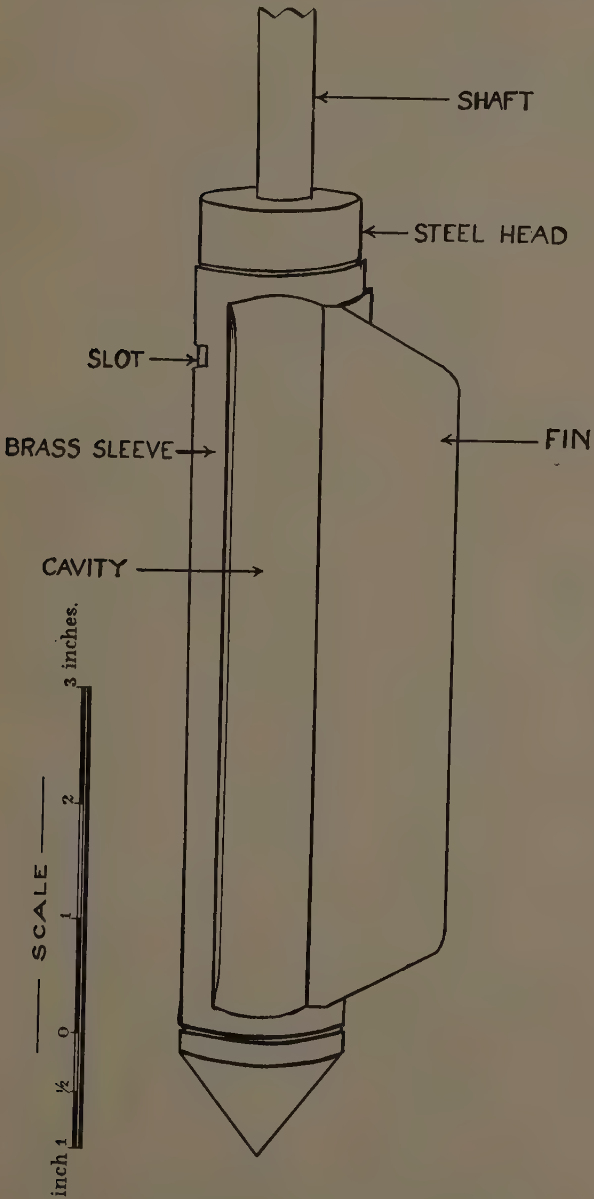


FIG. 1.—Modified Frankel Borer used in sampling muds in the Lake Albert Survey.

PLATE 5.

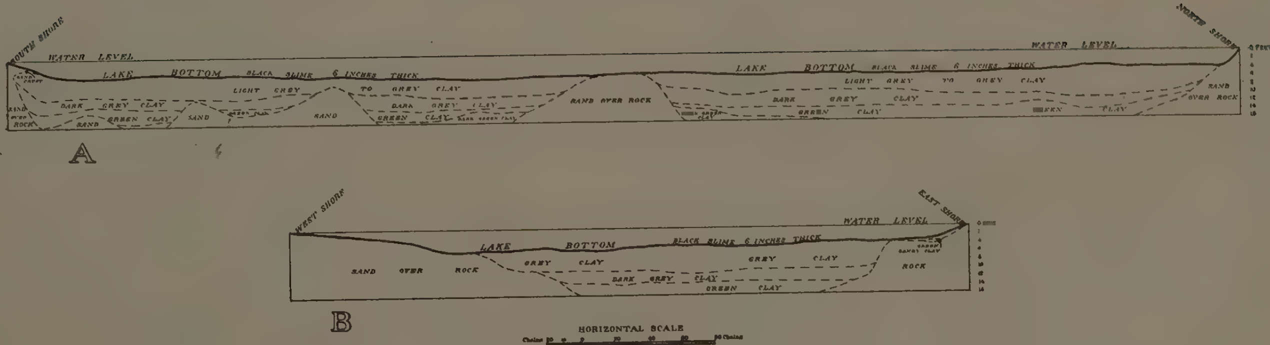


FIG. 2.—Cross sections of Lake Albert.

A—South to North.
Warringee Hut to North Red Flag.

B—West to East.
Rumplyander House to May's Hill.

PLATE 6.

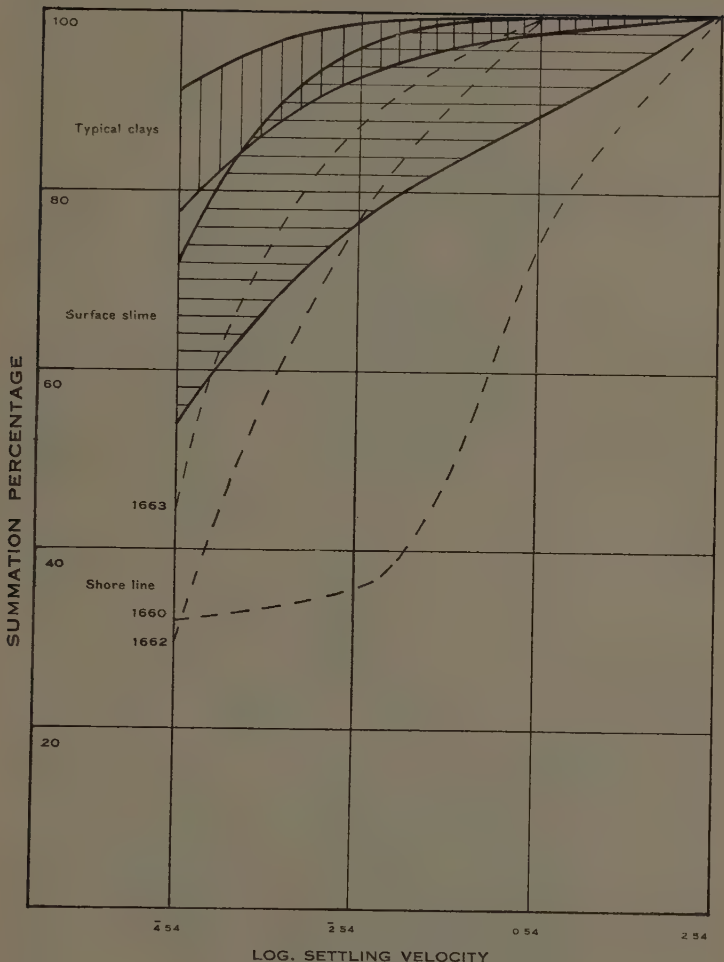


Fig. 3.—Summation curves showing ranges of mechanical analyses of Lake Albert muds.

PLATE 7.

FIG. 4.—Soil map of Lake Albert.

PLATE 8.

(Portable Field Apparatus for the Estimation of Chlorides in Soils. See page 122.)

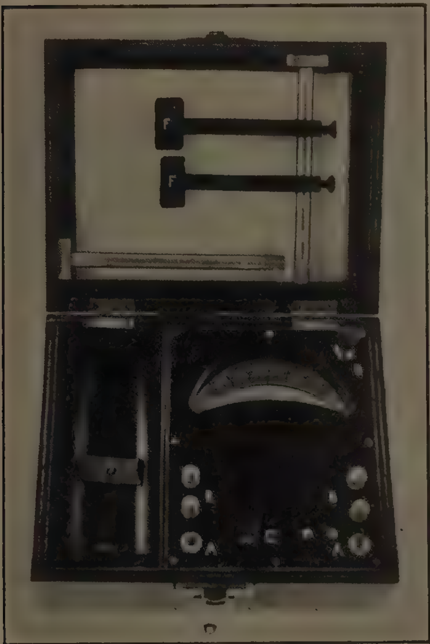


FIG. 1.

EXPLANATION OF LETTERING.

A Brass collars with thread to take uprights E.

B Terminals to galvanometer. The two pairs are connected in series so that a pair will be conveniently near to the electrode system, whether this is placed on the right or left hand side.

C Tap key in the galvanometer circuit. This may be permanently open, permanently closed, or used as a tap key.

D Device to clamp the galvanometer needle during transit.

E Brass uprights which screw into A, and carry clips F, &c.

F Spring clips to carry the electrode system and burette.

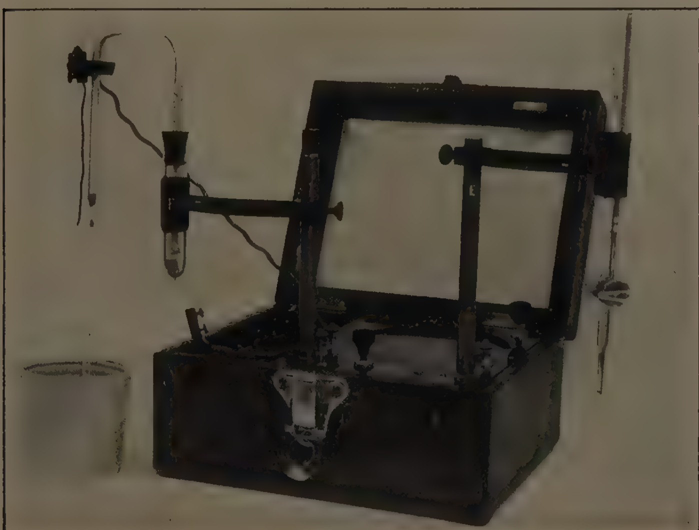


FIG. 2.

PLATE 9.

(Memorial to the late Dr. E. S. Bieler. See opposite page.)

NOTES.

Geophysical Prospecting : The late Dr. E. S. Bieler.

Shortly after the establishment of the Imperial Geophysical Experimental Survey to carry out a two-years' programme of work in Australia, a Canadian physicist, the late Dr. Etienne S. Bieler, was appointed as its Deputy Director. He reached Australia in July, 1928, and some few months later had complete charge of the work in the absence from the country of the Director of the Survey, Mr. A. Broughton Edge. It was during this period that he had occasion to visit a field party stationed at Northampton, Western Australia. He did not quite reach the party, however, for, feeling unwell at the small town of Geraldton, some 240 miles north of Perth, he went into hospital there on the 23rd July, 1929, and died two days later of acute pneumonia. He was buried in the local cemetery.

Dr. Bieler had a brilliant scientific mind, and by his lamentable death, Canada, and the British Commonwealth as a whole, were deprived of the services of one they could ill afford to lose. He was born in Switzerland in February, 1895, but early in his boyhood his family removed to Montreal, Canada. He had entered the McGill University before the war, but early in 1915 he enlisted with the Canadian Forces, and saw considerable war service in France, first with the infantry, and then with the trench mortars. After being twice wounded, the second time rather seriously, he served with the Anti-Submarine Division of the Admiralty.

In 1920, he won an 1851 Exhibition Research Scholarship, and proceeded to the Cavendish Laboratory, Cambridge, where, under the direction of Sir Ernest Rutherford, he obtained his Ph.D. degree for work connected with the ultimate structure of the atom. Returning to McGill as Assistant Professor of Physics, he became interested in geophysical prospecting, chiefly by electrical methods, and in the brief time before coming out to Australia, had already been responsible for notable improvements in that field.

His appointment to the Survey meant that the experience and knowledge available to that body were considerably augmented. The appointment was also very appropriate in that the Survey was an Imperial undertaking, and in normal circumstances the return of Dr. Bieler would have meant much to the further development of geophysical prospecting in the particular part of the Empire he represented.

Dr. Bieler by no means confined his activities to science. He was a man of wide reading, and had many interests in common with his fellow men. Shortly after his burial, his friends of the Survey, and of the Executive Committee which controlled it, combined to erect a simple memorial over his grave. With the assistance of several Geraldton and other Western Australian people, who very kindly gave their services quite gratuitously, the memorial has recently been completed. The main object of the Survey was to investigate and to demonstrate the possibilities of prospecting by geophysical means with a view to the greater development of every portion of the British Commonwealth, and to the improvement of the general well-being of their people. Australia may well remember one from a sister Dominion who gave his life to that

end, and we think that readers of this *Journal* will feel more than a passing interest in the photograph of Dr. Bieler's memorial, which is reproduced on Plate 9.

The Buffalo Fly Problem—Recent Developments.

For some time past, the buffalo fly, which for years has been a troublesome pest in North Australia, has been spreading slowly towards Queensland. It has also been extending westwards, but perhaps not to the same extent. To the south, and not far from Darwin, a natural barrier apparently exists in plateau country where the aridity and other climatic conditions seem effectually to stop its spread. Along the narrow coastal belt towards Queensland, however, the spread has been all too sure, and at the present time the fly is firmly established in Queensland itself. Once it reaches the railhead, nothing can be done to prevent its rapid spread throughout the regions climatically suited to it. It may reach as far south as Sydney, or even further. The serious economic losses that are in the balance are thus obvious, particularly when the importance of the dairying industry in the coastal country to the north of Sydney is remembered.

Authorities having the necessary powers to declare quarantine lines and zones have made one or two attempts to stop the further eastward spread of the fly, but the difficulties of controlling a flying insect by such means are naturally many. Towards the end of last year, the Council's Division of Economic Entomology made a study of the eastward advance with a view, *inter alia,* of obtaining information that would be of value to it in connexion with its general investigation of the possibility of controlling the fly already in North Australia. The extent of the spread of the pest thus revealed, in comparison with its limits as defined by a previous survey carried out by State authorities two years previously, made the gravity of the menace still more apparent.

The Council has naturally kept the Government and the authorities having the power of quarantine fully advised of the position, and has repeatedly expressed its view of the seriousness of the position. So serious, indeed, does it regard the present situation, that it has withdrawn two of its limited team of entomologists (Dr. Mackerras and Mr. Campbell) from their normal programme of investigation, and has made their services freely available to the quarantine authorities to render any assistance possible on the entomological side. Naturally, such authorities will want to know whether the fly already exists in any buffer or quarantine zone that might be suggested. Such information can best be obtained by entomologists, like those of the Council, who are experienced in the identification of the fly.

The Government authorities concerned now desire to proclaim a new buffer zone to the east of the former quarantine line. At their request, Dr. Mackerras and Mr. Campbell left Canberra for Queensland towards the end of April. They will proceed to the extreme north-west of the State immediately, and will then commence their survey of the eastern boundary of the present infestation.

It should be emphasized, however, that the Council will be concerned with entomological survey work only, and will in no way be concerned —nor has it the power to be—with the executive side of the new buffer zone scheme.

Agricultural Economics—The Humbert-Marie Jose Prize.

A Prix Humbert-Marie José consisting of a gold medal, plus the sum of 10,000 lira, was instituted on the occasion of the marriage of H.R.H. the Heir Apparent of Italy to H.R.H. Princess Marie José of Belgium. It will be granted annually, the first award having been made on the 31st December, 1930. The time for the receipt of applications expires on the 30th September each year.

The award of the prize itself is controlled by the International Institute of Agriculture, in which H.M. the King of Italy has taken a very keen interest, and towards which he makes very substantial financial contributions each year. The remaining funds of the Institute are provided from the contributions of the various adhering countries. Australia has contributed in this way for many years, but the whole question of her further participation is now under consideration.

The most important conditions relating to this newly-established prize are given in the paragraphs that follow.

In the first place, the competition will be open only to competitors within the jurisdiction of the countries adhering to the Institute, and who have published the work they desire to enter within the two preceding years. When any particular paper has been published in several parts, the whole will be eligible for competition for the period for which the last part is eligible. Further, a new edition of a previously published paper will only be admitted to the competition if the alterations or additions which have been made to the first edition are very considerable. As to a subject, this must be chosen from the general field of agricultural economics and statistics.

Should any Australian seriously consider becoming a competitor, he would be well advised, before commencing on the preparation of his thesis, to consult the Council for Scientific and Industrial Research for further precise information.

A New Instrument for the Rapid Determination of Moisture Content in Timber—The Blinker.

During the last few years, the Forest Products Laboratory at Madison (U.S.A.) has been developing and improving a very simple instrument for the rapid determination of the moisture content of timber (and thus the degree of its seasoning). As the application of the instrument to Australian timbers is now under investigation by the Council's Division of Forest Products, and as in any case the method may be of general interest as a typical instance of the present day application of science to industry, the following brief account of the principle on which the instrument depends is printed below. It will be obvious, too, that the application of the instrument need not necessarily be confined to timber.

In the first place, it has been found in the United States of America that the electrical resistance of any particular piece of timber bears a ratio to its moisture content that varies within very narrow limits, irrespective of what species of timber the particular piece may represent. It therefore follows that if the electrical resistance of any piece of timber is known, its moisture content to a fair degree of accuracy is

also known. In practice it is not necessary, of course, actually to determine the electrical resistance, for an instrument can easily be devised to record moisture content directly.

In the apparatus developed by the Forest Products Laboratory of Madison, current from a battery flows through a fixed resistance and then to a condenser and to a neon lamp arranged in parallel. A switch is also provided in the circuit. When the latter is closed, current flowing through the resistance gradually builds up a voltage difference between the plates of the condenser, and thus those between the terminals of the neon lamp, until the ionization potential of the latter is reached. At this point, a flash of light occurs in the tube, some current passes, and the voltage difference between the plates of the condenser is reduced. The battery, however, soon builds up this voltage difference again, and the result is that a series of flashes occur in the tube as long as the circuit is closed. By a suitable arrangement of resistance, condenser, and tube, these flashes can be made to occur at intervals of say one second.

The instrument contains a second circuit similar to the foregoing, with the exception that the resistance is replaced by a hammer containing two or more contact points. These when driven into the wood complete a circuit, and flashes in the tube of the second circuit occur—rapidly if the resistance of the timber is low—and thus its moisture content high—and slowly if the resistance of the timber is high. By switching in a number of different capacity condensers into the second circuit one after another, the rate of flashes in both lamps can be made the same. The values of the different capacity condensers instead of being expressed in microfarads are expressed in moisture contents. Accordingly, the moisture content of any particular piece of timber can be determined in the course of a few seconds.

Although such an instrument is obviously of considerable industrial value, it must be used with caution. It does not provide a complete substitute for the more laborious oven-drying method of determining moisture content. When used without a true knowledge of seasoning and the effect of moisture upon the physical properties of wood, the indications can in some cases be so erroneous as to be disastrous. On the other hand, with proper care, the electric moisture meter is likely to be a very useful instrument for use in connexion with seasoning; and providing its limitations are recognized, it will be of considerable assistance for such work as the rough sorting of timber consignments into green and drier portions, or in indicating the general conditions of a consignment.

On behalf of an Australian saw-miller, the Division of Forest Products recently had an instrument built by the Research Section of the Postmaster-General's Department. The apparatus is now under test by the Division with a view to ascertaining the extent to which an instrument known to be very useful in the case of timbers of the Northern Hemisphere will be effective when used with the rather unique woods common to Australia.

The Division has also been provided by the local agents with a Tag Heppenstall moisture meter for similar tests as to its applicability to Australian timbers. This particular apparatus also operates by measuring the resistance of timber, but a different circuit is used involving thermionic valves for current amplification, the final results being read off on a series of contact points after bringing a milliammeter to a constant reading.

Investigations on Dried Fruits (Currants and Sultanas).

In August of last year, a Conference, representative of the Governments concerned and of growers of dried grapes, was held in Melbourne to discuss the stabilization of the industry in view of its serious economic condition. One of the numerous resolutions the Conference carried with that end in view constituted a recommendation that the services of the Officer-in-Charge of the Council's Research Station at Merbein (Mr. A. V. Lyon) should be made more freely available to the dried-fruit industry throughout Australia for advisory work in regard to dipping, irrigation, cultural, and packing practices.

Arrangements have now been made to free Mr. Lyon for a greater proportion of his time than formerly, in order that he may give attention to these matters in co-operation with other interested organizations. The question of standardized dips has been referred to the Committee (*see* Vol. 3, p. 161) dealing with the sulphuring of apricots, and the recommendations of the Committee have already been issued to the industry. As regards the other matters, further investigational work is involved. Mr. Lyon is, however, now assisting different Irrigation Advisory Boards with technical advice in respect to the periodicity and the method of irrigation and with the carrying out of a programme of investigational work concerning the modification of the frequency and methods of irrigations, as these are affected by soil types, climate, season, and crop requirements. As regards the improvement of cultural practices (methods of pruning, &c.), the work of the Merbein Station has for quite a number of years led to results of value in this connexion, and it will, of course, be continued.

Another matter which the Council has under consideration at the present time is that of further investigations into the dried-fruit grub pest. Advice from England indicates that this problem is still far from solved, and from time to time leads to not inconsiderable losses to the Australian grower. At the same time, the trouble could be overcome by the use of insect-proof containers, but, unfortunately, suitable yet economic packings of this nature are not easy to produce in the case of dried fruit. The precise lines of any work that may possibly be undertaken in Australia are still under consideration.

The initiation of the additional investigational work outlined above has been rendered possible only by the generous grant to the Council of an amount of £1,000. This sum has been made available by the Dried Fruits Control Board.

Canary Stained Wool.

The Wool Industries Research Association of Great Britain has recently been giving some attention to the question of canary stain in wool, i.e., to the yellow colour which, for some reason or other, occasionally develops in growing fleeces, and which cannot be very easily removed. For some time past, the colouring has been believed to be due to the action of bacteria.

The Research Association has now isolated and identified certain varieties of bacteria probably causing the stain. It now desires to obtain further information regarding the occurrence of the phenomenon,

and with that end in view, it has recently sent a questionnaire to Australia. Copies of this have been sent to each State Department of Agriculture, and to the various Pastoralists Associations.

The replies, together with samples of wool affected by the stain, have been sent to Great Britain, where they are now being analysed and examined. The stain is far from widespread, and in some of the States does not occur at all. Judging from the replies received, there seems to be a rather general belief that the condition is due, or at any rate intensified, by wet weather. Some also believe that it is an heredity trait. There is little doubt, however, that the present work of the Association will throw further light on the matter.

Storage and Transport of Fruit—Visit of Mr. W. M. Carne to Great Britain.

An important matter to which the Chief Executive Officer of the Council (Dr. Rivett) paid attention in Great Britain during his recent visit was the development of investigations on food preservation and transport on the basis of Imperial team work. The discussions he had with the Director of the British Food Investigation Board (Sir William Hardy) all confirmed the previous opinions expressed that the very closest touch with the work of the Board was most desirable from the point of view of facilitating the successful prosecution of Australian work in the general field of food preservation and transport. Further, the cordial assistance any Australian investigators would receive if they were sent to the laboratories of the Board was made quite apparent.

It has now been arranged that Mr. W. M. Carne, of the Division of Plant Industry, will visit Great Britain. For some time past, he has been studying problems concerning the storage of apples, and in particular, bitter-pit. Through the kindness of the Peninsular and Oriental Steamship Company, the local agents (Messrs. John Sanderson and Company) have granted Mr. Carne a free passage on the SS. *Barrabool,* which left Australia on the 25th March. The ship is carrying a cargo of apples, and Mr. Carne will be able to obtain many valuable observations on the conditions of fruit transport and of their marketing in Breat Britain. Before he returns, he will make himself conversant with the investigations of the British Food Investigation Board, and will also visit other research organizations, such as the Horticultural Research Station at Long Ashton. It is hoped to make arrangements for him to return to Australia via South Africa, in order that he may become familiar with the organizations and practices of the fruit export industry of that country.

Mr. Carne's visit will form part of the investigational work to be undertaken as a result of the grant of £6,000 per annum by the Empire Marketing Board mentioned below.

Plant Problems—Empire Marketing Board's Grant of £6,000 per annum.

The Empire Marketing Board has recently decided to make to the Council the generous grant of £6,000 per annum for a period of two years for the assistance of certain portions of the work of the Division of Plant Industry. The activities that will be so helped are those concerning fruit, cereals, and pastures.

Some time ago, the Division made a commencement in a small way in investigations of this nature. Mr. W. M. Carne's work on bitter-pit and other storage diseases of the apple is typical of the fruit work the Board intends to assist. The work on cereals will consist of some investigations in the field of plant breeding as already decided on by the Council's Standing Committee on Agriculture. The precise lines of the agrostological work that will be undertaken are now under consideration.

Division of Plant Industry—Duntroon Farm Area.

The Council has been faced for some time past with the problem of providing a suitable area for the necessary experimental plots, &c., for its Division of Plant Industry at Canberra, the soil of the small area towards Black Mountain behind the laboratories of the Division being of a somewhat inferior and rather variable quality.

The problem has now been solved by the Department of Home Affairs granting the Council a lease, rent free, of portion of the farm area of the former Duntroon Military College, which has recently been transferred to Sydney. The portion so made available to the Council comprises about 100 acres of some of the best soil in the Federal Capital Territory. It also includes the homestead and barns. The Council is particularly gratified in obtaining the use of this area, as, in addition to being developed already, it is only some 4 miles or so distant from the laboratories.

Recent and Forthcoming Publications of the Council.

Since the last issue of the *Journal,* the following publications have been issued:—

Pamphlet No. 18.—"The Influence of Frequency of Cutting on the Productivity, Botanical and Chemical Composition, and the Nutritive Value of Natural Pastures in Southern Australia." Progress Report on Co-operative Investigations at the Waite Agricultural Research Institute, by J. Griffith Davies, B.Sc., Ph.D., Agrostologist, and A. H. Sim, B.Sc., B.Agr.Sc., Chemist.

The following publications are now in the press:—

Bulletin No. .—Radio Research Board, No. 1, Paper No. 1.—"Corrections to Field Strength Measurements with Loop Antennae," by W. G. Baker, B.Sc., B.E.; Paper No. 2.—"A Radio Field Strength Survey within 100 Miles of Sydney," by W. G. Baker, B.Sc., B. E., and O. O. Pulley, B.Sc., B.E.

Bulletin No. .—"The Experimental Error of the Yield from Small Plots of Natural Pasture," by J. Griffith Davies, B.Sc., Ph.D.

Bulletin No. .—"Factors Affecting the Mineral Content of Pastures, with Particular Reference to the Environmental Conditions Incidental to Southern Australia," by Professor A. E. V. Richardson, M.A., D.Sc., H. C. Trumble, M.Agr.Sc., and R. E. Shapter, A.A.C.I.

The Occurrence and Distribution of Salinity in a Virgin Mallee Soil.

By J. E. Thomas, B.Sc., B.Agr.Sc., B.V.Sc., Commonwealth Research Station, Merbein.

Errata.

Two errors occur in the above article, which appeared in the previous issue. In Table 3, on page 16, the total SO_4 content for the sample at a depth of 5-6 feet, should read 1.235 per cent.

The plates in Figs. 7 and 8 facing page 55 have also been transposed, as will be apparent from a study of the relative heights—above a common datum level—of the contours shown in the two plates.

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